iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2026 **Issue:** Conference **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83191

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com
National Conference on Integrated Approaches to Sustainable Innovation 2026 (IASI 2026)

Low-Cost Real-Time Waste Monitoring Using IoT

Sajan Kumar Yadav, Pratima Das, Sandip Kr Dhara, Abhisek Manna, Tinkar Gayan
Electrical Engineering, Maulana Abul Kalam Azad University of Technology

Abstract— World Bank reported that in the year 2050, generation of waste will be reached 3.4 billion tonnes per year. So, waste management is a challenge to the world as well as India. It is very difficult to monitor waste in urban and semi urban areas, since it covers very large area. In this paper we design a low-cost real-time monitoring system to manage the waste. To segregate the waste, two dustbins has been kept, one for biodegradable waste another for non-biodegradable waste. A level sensor and GSM module have been installed to each dustbin, when the dustbin will be filled out a message will be sent to the operator through the GSM module. The power to run the level sensors and GSM module a solar system has been installed within the dust bin. When the operator will get message, the operator will take necessary step to vacant the dust bin. After few months the fill, out of dustbin's pattern will be recognized as a result waste collection will be minimized.

I. INTRODUCTION

Due to population growth the waste also increases, a world bank report says global wise waste will be reach 3,4 billion tonnes per year by 2050[1]. This amount of waste will effect on environment and health of animals, so it is a challenge to us, to manage this huge amount of waste, especially the developing country like India. However, in India the infrastructure is not appropriate to manage huge amount of waste [2] to manage huge amount of waste it is needed to segregate the waste, we know that in India the various types waste is there as like biodegradable, no- biodegradable recyclable etc. A central report of pollution control in India says that a large amount of waste in India are collected in mixed form, as a result it is decreases the efficiency of recycling process since it is unable of recycling it is cause of land filling .[3] However, due lack of waste management in India, it is being a major cause water pollution, increase greenhouse gases, poising the soil .[4] To overcome this problem in India, especially in semi urban and Urban area it is needed to monitor the wastes in real time. To monitor the waste in real Internet of Things (IoT) based approached is most promising technology now a days [5] this system can detect the type of waste material and it generate data to manage the waste centrally. However the technology is most costly [6] the governments of India implemented a rule in 2016 named as solid state management rule, according to rules the waste must be segregated at least in three forms biodegradable, non-biodegradable and domestic hazardous, these rule substitute of 2000, in 2000 rule urban and semi urban area was not included, it is being added in 2026 rule.[7] Public awareness also a factor to implement a mechanism to manage the waste, now a days in India due to limited public awareness it is unable to implement a IoT based waste management in a large scale [8] Since, public awareness a major issue in India, so segregation is big factor to manage the waste , so, segregation mechanism take a major role to manage the waste in India [9]. However, using machine learning, it is possible to increasing efficiency by reducing human intervention.[10] To make the IoT system more user frankly, a mobile application, web application has been developed. [11] The goal of United Nation of waste segregation Monitoring system for urban local bodies are, using IoT system and analysing to monitor the segregation process and real time feedback and optimizing the collection process by data analysis.[12] However, by integrating the Geographic Information Systems in IoT based waste management system, give a analysis of route map and optimizing the efficiency of operation. [13] For economic growth the countries are giving the importance of waste recovery and recycling a report by MacArthur Foundation highlights the necessity of recycling of waste to reduce the waste and pollutions.[14]

II. WORKING METHODOLOGY

In the system at first ultrasonic sensors generate a signal continuously in the dustbin and send the signal. Here, there are two dustbin, dustbin-A is for Bio-degradable and Dustbin-B for Non-degradable, in both dustbin ultrasonic sensors are install to monitor continuously, the signal generated by the ultrasonic sensors send to S3 microcontroller, the controller read the data and compare with threshold value and according to that process a signal. If the distance measured by the ultrasonics sensors are less than the preset value then the ultrasonic sensors generated an alert signal that the dust bin full or partially full, now if the distance measured by the ultrasonic sensors are greater than the threshold value then the dustbin is empty.

©IJRASET: All Rights are Reserved

Once the data is being processed by the microcontroller This process data is being sent by UART communication through Quectel EC200U GSM module, the cloud server receives the data and show in the dashboard. Here, two dustbin is being used to segregate the bio-degradable and non- biodegradable waste, in both dustbin the ultrasonics sensors has been installed. Two sensors' data have been faceted with the microcontroller simultaneously and send individual status signal for each dustbin.

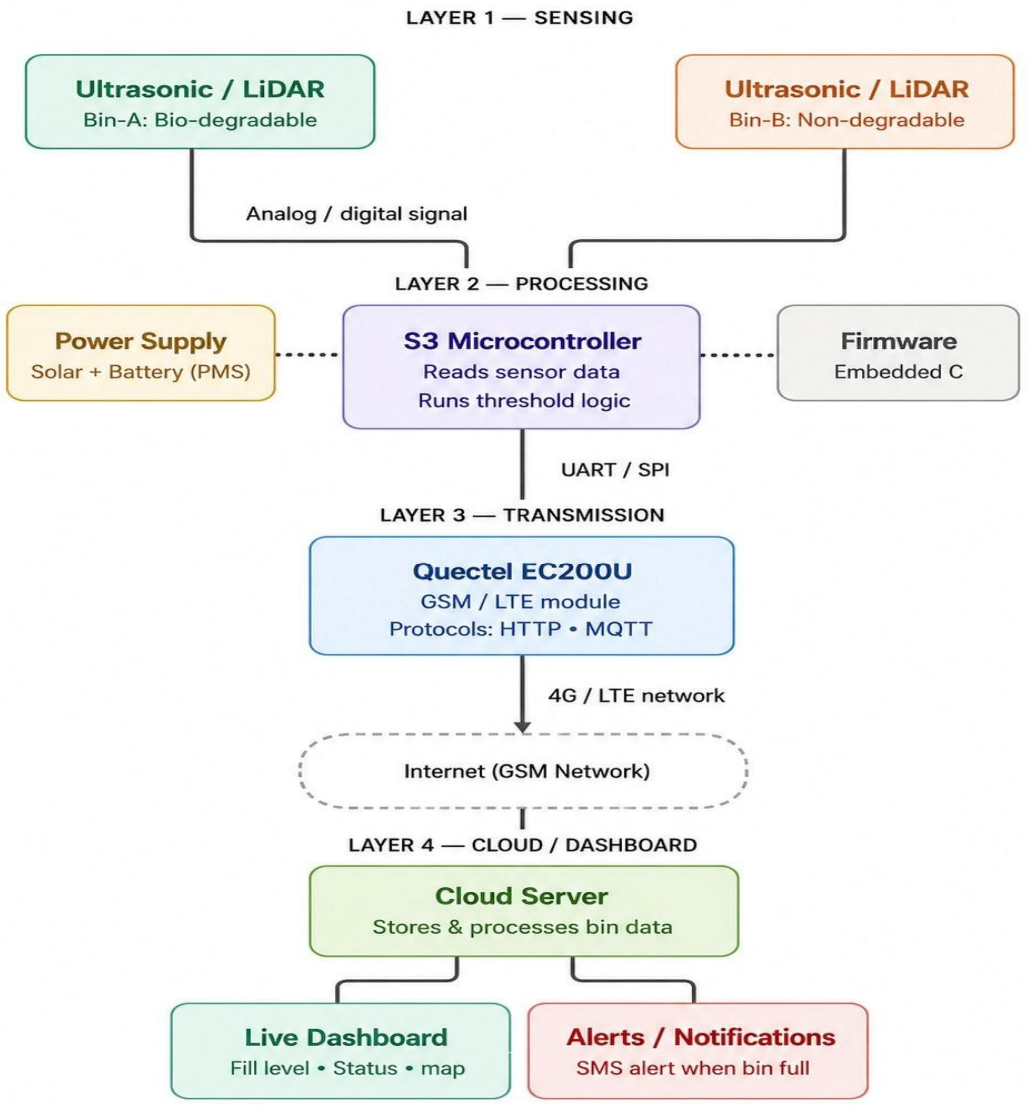


Figure 1. Flow chart of the system

III. WASTE LEVEL DETECTION

Ultrasonic sensors are used to detect the dustbin are fill out or not. Here ultrasonics sensors are being used because, ultrasonic sensor is not affected by colours or transparency and its cost is low. It has high reliability and lighting conditions, over than the others sensors like optical sensors, an ultrasonic sensor can measure accurate distances does not depend on the material of the waste. The sensors emit a frequency, in form of sound wave and this sound wave is being comeback by reflecting from the obstacle, in generally ultrasonics sensors emits frequency of above 20kHz towards the surface of the waste in the dustbin, by using the formula [Distance=Time ×Speed/2], here speed represents velocity of sound in air, which is 343m/s at room temperature, Time is the total time taken by the ultrasonics wave to travel from obstacle to return back to the receiver, the whole terms is divided by 2 to round trip the sound wave journey.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

However, obstacles distance has been measured; by time taken for the emitted signal to return after reflection which is also known as time of flight, by measuring the distance of waste material it is being decided the dust is being filled out or not. Here, ultrasonic sensors JSN-SR04T has been used.

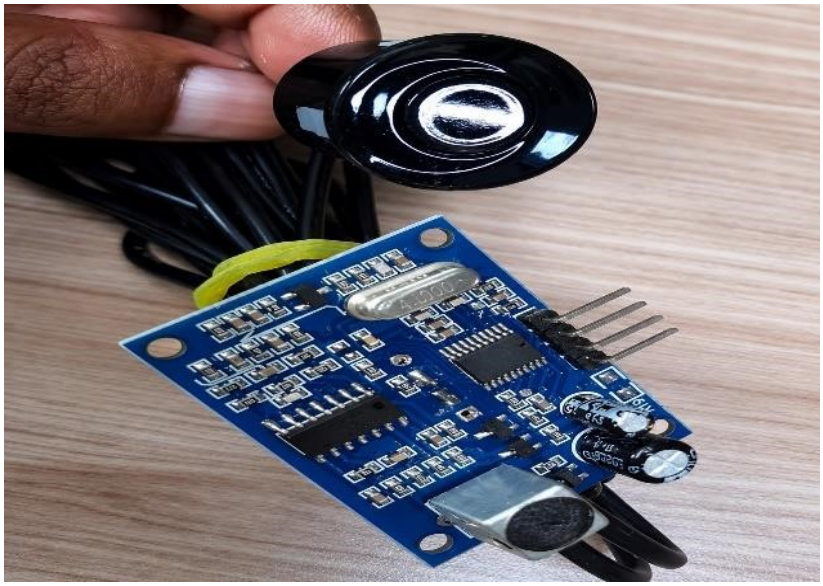


Figure 2. Ultrasonic sensors JSN-SR04T

IV. DATA ACQUISITION AND PROCESSING

The data is being sent by ultrasonic sensor is take a crucial part to make decision that the dustbin is full or empty. The sensors continuously measure the distance of waste material position and this measured distance has been fetched with S3 microcontroller, ESP32-S3. Here, ESP32-S3 is the central processing unit. The microcontroller has been processing the data and prepare the data for further communication and storage. One of the major advantages to use the microcontroller ESP32 -S3 is, it can handle multiple tasks as like sesors interfacing, data processing, communication within a single platform. However, the ultrasonic sensors measure the level of waste, threshold logic is being used, if the distance of waste is less than a set point then it gives a message that the dustbin is full, otherwise it is empty. Here, microcontroller ESP32-S3 is being used for its efficiency is high and power consumption is low over than others microcontroller The microcontroller powered by solar panel with a battery. The solar energy ensures uninterrupted operation and sustainability of the system. Here a photovoltaic solar panel has been used which charge a rechargeable battery in day time. Not only the microcontroller but also ultrasonic sensors and communication module also powered by the battery. As a result, the system is not dependable on conventional power source, so it can be installed to a remote area where only sunlight is available where grid power is not available. To ensure its performance and protection the whole system is put inside an IP65 rated enclosure. This enclosure protects form dust ingress and water exposure and this enclosure ensure reliable operation even in very harsh outdoor environments. That is why the system's stability and longevity is good, which is need for real time motioning system The logic and overall system of the microcontroller is being written in embedded C language because it is low level language, it has minimal memory footprint in microcontroller. Which properties are very essential for a microcontroller-based systems, where basically computational resource is very limited. Here, embedded C makes precise control over input/output operations, sensors interfacing and decision-making process, which increases the performance of the system and it be more responsiveness. So, here the ultrasonic sensors are threshold-based decision making and it is powered by solar energy, programmed are embedded which makes the system cost effective robust for the real time waste monitoring applications.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

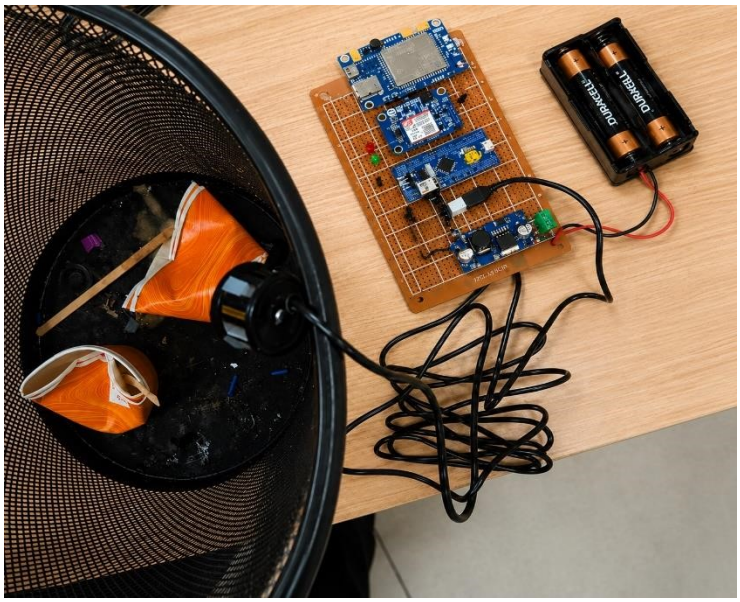


Figure 3. Microcontroller fetching data from the sensors

V. TRANSMISSION & CLOUD DASHBOARD

Collected data has been transmitted to the waste management operator. The microcontroller sends the collected data from the ultrasonic sensors through Serial Communication Protocols to QuectelEC200U, it is LTE module that connect to 4G cellular network. Next the data has been pushed to the cloud through Hypertext Transfer Protocol the data has been send to client and client to server as per required. A web base dashboard devolved to display the data, the dashboard will display the real-time information of the waste status of the dustbins and the location of the dustbins. The operator of waste management will identify which dustbins are required to make empty immediately. However, the system developed an alert notification through message, when the dustbins are fill out. The cloud base system ensures seamless dataflow from the sensor to the waste management operator. Since, the system have real time monitoring, data analytics, smart decision making capabilities, so this makes the system highly effective waste management system.



Figure 4: Wireframe of Dashboard

VI. CONCLUSIONS AND FUTURE SCOPE

The system is a comprehensive design of a low cost IoT- based waste monitoring system especially for urban area. Through the system the waste can be monitor continuously and accurately. The real time data has been transmitted from different places and controlled by centralized platform. By using dashboard, the data has been visualized, so it makes easy decision making. Since the population, in urban area is very low, so the dustbin is not being fill out in a single day, it may take several days where others may fill out faster. The dustbin is placed at large geographical areas as a result it is difficult to monitor manually. This problem has been solved through the system; this system provides location specific real time status update. So, it is more efficient to urban area where proper monitoring system is unavailable. However, by analyzing the data, it is possible to make a pattern of waste accumulation, as like one dustbin fill up consistently due to high uses where other may not fill up faster because of less uses, these insights may be used to optimize waste collection path which reduces unnecessary trips and placed resource more effectively. So, this waste management system will not only reduce the cost or fuel consumption but also environmental impacts.

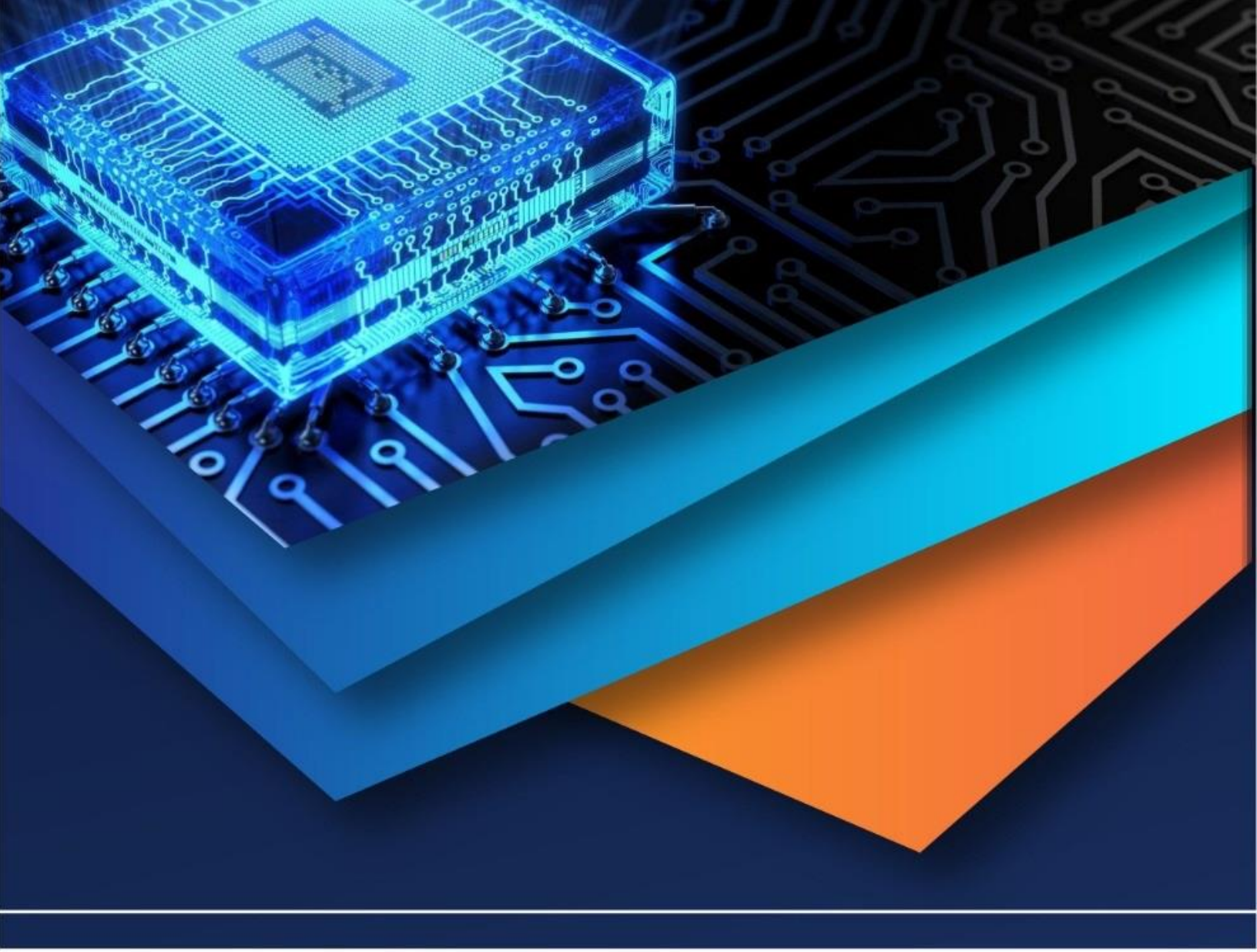
In future it can integrate to AI based predation model to optimizing the waste collection process. AI or Machine learning can be used to forecast waste generation pattern based on previous data, seasonal variation, population behaviors. In future, the AI based perdition model will be able to make a proactive waste collection strategies, where scheduled of collection will be done before fill out a dustbin.

However, this IoT base waste monitoring system gives a reliable, scalable and smart solution for modern waste management challenge, however by integrating AI based model and machine learning the system will be more efficient, more sustainable, more effective to manage the waste

REFERENCES

[1] S. M. Metev and V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
[2] J. Breckling, Ed., The Analysis of Directional Time Series: Applications to Wind Speed and Direction, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.
[3] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," IEEE Electron Device Lett., vol. 20, pp. 569– 571, Nov. 1999.
[4] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in Proc. ECOC'00, 2000, paper 11.3.4, p. 109.
[5] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to- RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.
[6] (2002) The IEEE website. [Online]. Available: http://www.ieee.org/
[7] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: http://www.ctan.org/texarchive/macros/latex/contrib/supported/IEEEtran FLEXChip Signal Processor (MC68175/D), Motorola, 1996.
[8] "PDCA12-70 data sheet," Opto Speed SA, Mezzovico, Switzerland.
[9] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
[10] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.
[11] Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, IEEE Std. 802.11, 1997. [12] M. Yang and G. Thung, "Classification of Trash for Recyclability Status," Stanford Technical Report, 2016
[12] S. Rovetta et al., "Early Detection and Evaluation of Waste Through Sensorized Systems," Waste Management, 2009

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)