**Smart Waste Management using Internet-of-Things (IoT)**

**Authors:** Gopal Kirshna Shyam1, Sunilkumar S. Manvi2, Priyanka Bharti3

To make the cities greener, safer, and more efficient, Internet of Things (IoT) can play an important role. Improvement in safety and quality of life can be achieved by connecting devices, vehicles and infrastructure all around in a city. We present a waste collection management solution based on providing intelligence to wastebins, using an IoT prototype with sensors. It can read, collect, and transmit huge volume of data over the Internet. Such data, when put into a spatio-temporal context and processed by intelligent and optimized algorithms, can be used to dynamically manage waste collection mechanism. Simulations for several cases are carried out to investigate the benefits of such system over a traditional system.Intelligent waste collection system t is responsible for measuring the waste level in the wastebins and later send this data (through Internet) to a server for storage and processing. This data helps to compute the optimized collection routes for the workers. In future, we would like to enhance the system for different kind of wastes, namely solid and liquid wastes.

**AUTOMATION OF SMART WASTE MANAGEMENT USING IoT TO SUPPORT “SWACHH BHARAT ABHIYAN” – A PRACTICAL APPROACH**

**Authors:** 1Bharadwaj B, 2M Kumudha, 3Gowri Chandra N, 4Chaithra G

“Swachh Bharat Abhiyaan” is a national campaign by the Government of India, covering 4,041 statutory cities and towns, to clean the streets, roads and infrastructure of the country. The aim of the mission is to cover all the rural and urban areas of the country to present this country as an ideal country before the world. IoT module is used to control and monitor the waste and the information will be sent to the particular organization and the common man.

**Smart Waste Management System using IoT**

**Authors:** Prof. S.A. Mahajan, Akshay Kokane, Apoorva Shewale, Mrunaya Shinde , Shivani Ingale

With rapid increase in population, the issues related to sanitation with respect to garbage management are degrading immensely. It creates unhygienic conditions for the citizens in the nearby surrounding, leading to the spread of infectious diseases and illness. To avoid this problem, IoT based “Smart Waste Management” is the best and trending solution. In the proposed system, public dustbins will be provided with embedded device which helps in real time monitoring of level of garbage in garbage bins. The data regarding the garbage levels will be used to provide optimized route for garbage collecting vans, which will reduce cost associated with fuel. The load sensors will increase efficiency of data related to garbage level and moisture sensors will be used to provide data of waste segregation in a dust bin. The analysis of ceaseless data gathered will help municipality and government authorities to improve plans related to smart waste management with the help of various system generated reports.

1. This paper shows how the smart waste management using IoT can be implemented. This proposed system assures the collection of garbage soon when the garbage level reaches its maximum level.
2. The system will thus provide accurate reports, increasing the efficiency of the system. The real-time monitoring of the garbage level with the help of sensors and wireless communication will reduce the total number of trips required of GCV and thus, will reduce the total expenditure associated with the garbage collection.
3. Thus, the dustbins will be cleared as and when filled, giving way to cleaner city, better infrastructure and increased hygiene.

**Analysis of IoT-enabled Solutions in Smart Waste Management**

**Authors:** Sibongile Mdukaza,Bassey Isong, Nosipho Dladlu, Adnan M. Abu-Mahfouz

Internet of Things (IoT) has attracted widespread applicability not only limited to smart cities and communities but also in water, waste management and so on. It strength lies in the high impacts it created in the daily life and the potential user’s behavior. However, for it to be more effective and increase its adoption, it is require to be energy efficient, able to communicate and share information across extended coverage. IoT communication paradigm have provided the capability for devices to communicate and share information in long range distances while utilizing less power.

**IoT‑Based Smart Waste Bin Monitoring and Municipal Solid Waste Management System for Smart Cities**

**Authors:** Tariq Ali, Muhammad Irfan, Abdullah Saeed Alwadie1, Adam Glowacz2

Increasing waste generation has become a signifcant challenge in developing countries due to unprecedented population growth and urbanization. From the literature, many issues have been investigated that signify direct connection with the increase in waste material generation and related difculties to handle it in a smart city. These issues are the resultants of an improper collection and disposal mechanism used for waste material, the increase in moving trends of peoples toward big cities and lack of intelligent technology used to support the municipal solid waste management system. An IoT-based smart waste bin monitoring and municipal solid waste management system helps to solve the problems associated with management of waste material and the IoT-based waste collection for the smart city.

**Waste Management System Based On IoT**

**Authorss:**Sapna Suryawanshi, Rohini Bhuse, Megha Gite , Dhanashri Hande

Waste management is one of the primary problem that the world faces irrespective of the case of developed or developing country. The key issue in the waste management is that the garbage bin at public places gets overflowed well in advance before the commencement of the next cleaning process. It in turn leads to various hazards such as bad odor & ugliness to that place which may be the root cause for spread of various diseases.This waste Management System using IOT has implemented the management of waste in real time using smart dustbin to check the fill level of dustbin to check if it is full or not.The novel cloud-based system for waste collection in smart cities.Providing the services for the different kind of stake holders involved in this area.On-board surveillance cameras and reporting system.

**MONITORING THE SMART GARBAGE BIN FILLING STATUS: AN IOT APPLICATION TOWARDS WASTE MANAGEMENT**

**Authors:**Sirisha Yerraboina, Nallapaneni Manoj Kumar, K. S. Parimala, N. Aruna Jyothi

Garbage bins play a vital role in the waste collection process at the primary level itself. But the collected waste in the garbage bins must regularly be monitored, and from there it must be delivered to processing plants. This practice of continuous monitoring, transporting and processing contributes to the waste management. But the process of monitoring garbage bins would become difficult for the ones placed at inaccessible and remotely located sites. If such situations were prevailing continuously then the waste deposited in the bins will be increasing than to the accommodative levels resulting in spillover. Hence, there is a need for continuous monitoring of the garbage bins. In this paper, ‘Smart Garbage Bin’ (SGB) enabled with ‘Internet of Things’ (IoT) is developed. SGB’s generally embedded with the ultrasonic sensors used for sensing the garbage levels, information and communication devices that help in networking, interconnection, and data transfer.

**IoT-Enabled Solid Waste Management in Smart Cities**

**Authors:**S. Vishnu , S. R. Jino Ramson , Samson Senith , Theodoros Anagnostopoulos , Adnan M. Abu-Mahfouz , Xiaozhe Fan , S. Srinivasan and A. Alfred Kirubaraj

The Internet of Things (IoT) paradigm plays a vital role for improving smart city applications by tracking and managing city processes in real-time. One of the most significant issues associated with smart city applications is solid waste management, which has a negative impact on our society’s health and the environment. The traditional waste management process begins with waste created by city residents and disposed of in garbage bins at the source. Municipal department trucks collect garbage and move it to recycling centers on a fixed schedule. Municipalities and waste management companies fail to keep up with outdoor containers, making it impossible to determine when to clean them or when they are full. This work proposes an IoT-enabled solid waste management system for smart cities to overcome the limitations of the traditional waste management systems. The proposed architecture consists of two types of end sensor nodes: PBLMU (Public Bin Level Monitoring Unit) and HBLMU (Home Bin Level Monitoring Unit), which are used to track bins in public and residential areas, respectively. The PBLMUs and HBLMUs measure the unfilled level of the trash bin and its location data, process it, and transmit it to a central monitoring station for storage and analysis.

**IoT-Based Solid Waste Management Solutions**

**Authors:**Pardini , Joel J. P. C. Rodrigues , Sergei A. Kozlov , Neeraj Kumar and Vasco Furtado

With the increase of population density and the rural exodus to cities, urbanization is assuming extreme proportions and presents a tremendous urban problem related to waste generation. The increase of waste generation has been considered a significant challenge to large urban centers worldwide and represents a critical issue for countries with accelerated population growth in cities. The Internet of Things (IoT) and cloud computing offer an automation possibility through cyberphysical systems that will change the way solid waste management is performed. To achieve the transformation of traditional cities into smart cities, waste management becomes a critical element in achieving sustainability, efficiency in public spending, improving urban mobility, and preserving natural resources. . Using IoT, it is possible to track the location of waste containers, monitoring the level of garbage deposited, identify locations with the highest demand, suggest the shortest route for collection optimization of solid waste, or even interface with citizens to encourage disposal at times when the container can receive waste, which promotes citizenship and avoids significant problems resulting from the accumulation of garbage outside garbage collectors.

**IoT based solid waste management system for smart city**

**Authors:**Krishna Nirde , Prashant S. Mulay , Uttam M.Chaskar

Today, waste management from its inception to its disposal is one of the important challenges for the municipal corporations in all over the world. Dust bins placed across cities set at open places are flooding because of increment in the waste each day and making unhygienic condition for the citizens, to maintain a strategic distance from such a circumstance we have proposed wireless solid waste management system for smart cities which allows municipal corporations to monitor status of dustbins remotely over web server and keep cities clean very efficiently by optimizing cost and time required for it. As soon as dustbin has reached its maximum level, waste management department gets alert via SMS via gsm module placed at dustbin so department can send waste collector vehicle to respective location to collect garbage. The objective of the project is to enhance practicality of IoT based solid waste collection and management system for smart city.

**A Low Power IoT Sensor Node Architecture for Waste Management Within Smart Cities Context**

**Authors:**Matteo Cerchecci, Francesco Luti, Alessandro Mecocci, Stefano Parrino, Giacomo Peruzzi and Alessandro Pozzebon

An Internet of Things (IoT) architecture used to optimize waste management in the context of Smart Cities. A novel typology of sensor node based on the use of low cost and low power components is described. This node is provided with a single-chip microcontroller, a sensor able to measure the filling level of trash bins using ultrasounds and a data transmission module based on the LoRa LPWAN (Low Power Wide Area Network) technology. Together with the node, a minimal network architecture was designed, based on a LoRa gateway, with the purpose of testing the IoT node performances.

**IoT-Based Framework for Smart Waste Monitoring and Control System**

**Authors:**Sani Abba and Chinaka Ihechukwu Light

Environmental sanitation is very essential for healthy living. In our daily livelihood, garbage bins are usually kept without proper monitoring until they are filled to the point of overflowing onto the surroundings and spilling out, resulting in environmental pollution, which has serious health-related issues to human beings and the environment. In the present technological advancement, real-time monitoring and control of waste disposal is a challenging area that needs urgent attention by the research community. The traditional approach of monitoring waste in garbage bins placed in strategic locations is a very tedious and inefficient way that consumes time, human effort, and cost, and this is also not in agreement with smart city requirements.

**Waste Management and Prediction of Air Pollutants Using IoT and Machine Learning Approach**

**Authors:**Ayaz Hussain , Umar Draz , Tariq Ali , Saman Tariq , Muhammad Irfan , Adam Glowacz , Jose Alfonso Antonino Daviu , Sana Yasin and Saifur Rahman

Increasing waste generation has become a significant issue over the globe due to the rapid increase in urbanization and industrialization. In the literature, many issues that have a direct impact on the increase of waste and the improper disposal of waste have been investigated. Most of the existing work in the literature has focused on providing a cost-efficient solution for the monitoring of garbage collection system using the Internet of Things (IoT). IoT-based smart bin using a machine and deep learning model to manage the disposal of garbage and to forecast the air pollutant present in the surrounding bin environment. The smart bin is connected to an IoT-based server, the Google Cloud Server (GCP), which performs the computation necessary for predicting the status of the bin and for forecasting air quality based on real-time data.

**Smart Waste Management System using IOT**

**Authors:**Tejashree Kadus, Pawankumar Nirmal , Kartikee Kulkarni

The paper is based on the concept of Automation used in waste management systems under the domain of Cleanliness and Hygiene. Dumping garbage onto the streets and in public areas is a common synopsis found in all developing countries and this mainly ends up affecting the environment and creating several unhygienic conditions.Smart netbean uses multiple technologies firstly the technology for measuring the amount of trash dumped secondly the movement of the waste and lastly sending necessary signals and connecting the user to the WiFi system. Improper disposal and improper maintenance of domestic waste create issues in public health and environment pollution thus this paper attempts to provide practical solutions towards managing the waste by collaborating it with the use of IOT.

**Iot Based Drainage and Waste Management Monitoring and Alert System for Smart City**

**Authors:** Aarthi M,Bhuvaneshwaran A

To ensure the safety of the residents, the drainage system must be managed properly. Drainage monitoring teams aren't present in every region. As a result, the drainage status is checked on a regular basis. Intermittent inspections can cause flooding, clog drainage systems, and pay compliments.Controls that can be used by hand have been disabled as well. We need expert assistance, but we have a limited number of articles to track. Because of their lack of experience, operators are also unaware of the state of this manhole, which can result in an accident. The implementation and design goals of an intelligent real-time monitoring system for wastewater and waste management are described in this document using the Internet of Things.Surveillance in the dark is a difficult problem to solve. Various methods for monitoring and controlling underground drainage systems are proposed in this project. Realtime explanations of various applications such as underground drainage and manhole identification. Various parameters such as temperature, poisonous gas, flow rate, and water level are monitored and updated on the Internet using the Internet of Things.

**IoT Enabled Smart Waste Bin with Real Time Monitoring for efficient waste management in Metropolitan Cities**

**Authors:**Manju Mohan , RM. Kuppan Chetty , Vijayram Sriram , Mohd. Azeem , P. Vishal and G. Pranav

Background/Objectives: Waste bins are part of our lives for decades and mostly its condition are overflowing due to improper waste dumping, collection and management, which leads in foul smell and unhygienic condition, thus inherently results in environment pollution. Methods/Statistical analysis:Therefore, in this paper, design of a Waste Bin with real time monitoring is presented and a smart waste management system is proposed using the recent technical advancements of automation and Internet of Things (IoT). Findings: The capacitance sensor in the bin continuously monitors the level of the bin in real time and communicates to the central cloud where the bins are connected. Ultrasonic sensor is used to open and close the lid of the bin whenever the persons are nearby the bin. Such smart bins are connected to the cloud, where the bin status are communicated, recorded and monitored by the local bodies through and android app or a centralized server. Improvements/Applications: Thus the designed smart bin and proposed waste management system have better level of smartness compared to existing ones in metropolitan cities in a centralized manner.In most of the metro cities globally poses a challenge on effective waste solid waste management and maintenance of the waste bins.In this work an IOT enabled Smart Waste Bin with real time monitoring is designed and presented. In addition to the waste level measurement by using ultrasonic sensors, a sensing mechanism based on simple parallel plate capacitance is also developed and presented.

**IoT Based Solar Powered Smart Waste Management System with Real Time Monitoring-An Advancement for Smart City Planning**

**Authors:**Md. Humaun Kabir, Sujit Roy, Md. Tofail Ahmed &Mahmudul Alam

In this paper, we proposed an IoT based solar-powered smart waste management system which is suitable for any kind city or town in both developed and developing countries that can ensure proper collection, transportation, and disposal of household and industrial waste with real-time remote monitoring. To maintain the green and clean environment around us, precise collection and disposal of garbage in a regular fashion are necessary. The primary goal of this research work is to provide a complete smart solution for waste collection and disposal hence ensuring a comfortable environment.The implemented smart waste management system using Internet of Things (IoT) and cloud computing offered automation through cyber-physical systems, which can change the way of the waste management process. To keep our environment clean and dirt free by a smart solution,this proposed system can be very effective with the reasonable cost in terms of manipulating waste for any municipal and urban areas in both developed and developing countries. Both residential and commercial areas can be digitalized and modernized using this system, which can offer smart and green surroundings that can provide long life for the citizens.

**SMART SYSTEMS AND THE INTERNET OF THINGS (IOT) FOR WASTE MANAGEMENT**

**Authors:**Claude-Noel Tamakloe

Waste management is a raising concern faced by many nations in the world today. On the streets of major cities, it has become almost common to find waste which poses health hazards and other concerns to its communities and inhabitants. This project focuses on the use of smart systems and the Internet of Things (IOT), to provide an efficient and effective approach to waste management. This project designed and manufactured a prototype of a solar powered, self-compacting smart bin with a server side monitoring application. The prototype smart bin is capable of monitoring internal rubbish levels, compact it, freeing approximately 25% of the space with each compaction space. The bin also monitors total weight and is capable of sending all these information to a secure server side application. The accompanying web application monitors the state of each smart bin and proposes optimal routes for pick up. This approach will contribute to a smart and efficient waste disposal improving the cites waste management.

**IoT-Enabled Citizen Attractive Waste Management System**

**Authors:**Muhannad Al-Jabi, Mohammad Diab

Current cities worldwide have a goal to be smarter cities, but one of the most important challenges that faces cities nowadays is the waste processing. And there are two factors directly affect this challenge are: the increasing of urban areas and the rapid growth of population. So, it seems evident, the investment in involving the citizens in the interaction with any future waste management system will save a lot of money and efforts. Especially, in the developing countries, citizen needs some encouragement to interact with modern systems and make him use it in everyday life. Due to the growth of IoT technology, there is an increasing need and importance to design and implement waste management systems that attract and involve the citizens in the waste management process. The aim of this paper is to present the design of attractive waste management that uses IoT devices, RFID tags, weight and ultrasonic sensors to measure the citizen interaction with the waste management process.

**Smart Waste Management System (SWMS) based on Internet of Things (IoT)**

**Authors:**Kishendran A/L Muniandy, Ahmad Fakhri Ab. Nasir\* , Nurul Hidayah Razak, Asrul Adam, Muhammad Aizzat Zakaria

This research deals with the challenges in innovation of an IoT-enabled solution in monitoring and management of the environment. Waste collection utilizing the Internet of Things (IoT) with the technology of smart wireless sensors will enable us to gather field-level data from waste containers hence providing a waste monitoring solution that brings up a routing for waste collection. This paper proposed the web-based IoT solution by using NodeMCU and ultrasonic sensor to create a wireless prototype device to monitor waste bin level in real-time and route optimization solution by using Dijkstra’s algorithm which embedded in the Google Maps APIs.