Internet of Things (IOT) for Smart Waste Management in Himachal Pradesh, Western Himalaya, India

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Abstract: The concept of Internet of Things (IOT) is in trends in this modern era. In this smart phone era, the human life has increased influence of mobile phones applications. The concept of smart cities in India provides a window of opportunities to inculcate IOT applications for boosting governance. IOT based waste management system is one such concept which have great future prospects. In this paper, a framework for smart waste management system using IOT applications in the state of Himachal Pradesh, India has been proposed. With the advancing digitalisation and magnifying ICT (Information and Communication Technology) infrastructure in India, there arise many possibilities for implementation of IOT based smart waste management system. The state of Himachal Pradesh is a major tourist destination of Western Himalaya, India and there is approximately 304 metric tonnes of waste generation daily. This quantity of waste rises seasonally when lakhs of domestic and international tourists are added to this population every year. An internet based, well coordinated waste management will be a supplement to the beauty and better environment health of this state.

Keywords: Waste management, Internet of Things, Smart Waste Management, Solid Waste, etc.

1. INTRODUCTION

The term Internet of Things (IOT) was coined by Kevin Ashton in 1999, who was the director of auto - ID centre of Massachusetts Institute of Technology, USA. IOT can be defined as interconnection of various computing devices embedded in mobile phones, vehicles, building and other items. These devices have software and sensor which collect, compute and exchange data over a network. This enables efficient and accurate information usage with less of human efforts. IOT basically based on the concept of radio frequency identification i.e. RFID. It allows remote sensing and controlling of devices leading to integration of computer based systems for better efficiency and accuracy with reduced human efforts. Basically IOT works through an IP address allocated to devices on a network. IOT has a promising role for building a smart city with improved living conditions. The scope for IOT adoption may be seen in different sectors like industrial manufacturing, energy, agriculture, utility and transport, etc. The applications of IOT can be found in various facets like:

- Home automation.
- IOT of Medical Things for research and monitoring.
- Smart transportation for traffic control, toll collection, parking, safety and assistance.
- Vehicular communication system (vehicle to vehicle, vehicle to infrastructure).
- Industrial applications for manufacturing equipment, process control, supply chain networks.
- Environmental monitoring for monitoring of air or water quality, soil condition, earthquake or tsunami early warning systems.
II. NEED AND SCOPE OF IOT FOR WASTE MANAGEMENT
Waste management is a vital aspect of city management. It includes waste collection, segregation, recycle, reuse and disposal of toxic waste. With the deeper penetration of Information and Communication Technology (ICT) in our society, the data of each process of waste management can be collected and collaborated. This builds the foundation for IOT to provide smart solution for a more efficient and effective waste management system. Swachh Bharat Mission is a campaign of Govt. of India launched on 2nd October 2014, it aims for proper sanitation of cities, towns, roads and infrastructure of the country. Also digital India programme of Govt. of India, ensure that the government services are made available to citizens electronically by improved internet connectivity. Both these campaign hand in hand provides a firm platform for implementation of IOT based smart waste management system. The state of Himachal Pradesh struggling with garbage disposal problems. Approximately 304 metric tonnes of solid waste is generated everyday in this state. Himachal Pradesh is a major tourist attraction for domestic as well as international tourists. This makes it more important that this state should have an efficient waste management system.

III. PRESENT SCENARIO OF WASTE MANAGEMENT
To maintain the quality of life, proper waste management is one of the important aspects. In India, there still exists some inadequacy in this field due to some outdated practices. The basic strategy of waste management system follows a stepwise process. The waste from different social sectors is collected, segregated then the toxic waste is disposed of by incineration or in landfills and the reusable non toxic waste proceeds for recycling. The following picture depicts the whole process of waste management:

![Figure 1. Steps involves in Waste Management](image)

In the present times, the total population of Himachal Pradesh is about 7.12 lakhs in the urban area. The Urban Local Bodies (ULB) in this state are 54 in numbers, which are fractioned into 2 Municipal Corporations, 31 Municipal Councils and 21 Nagar Panchayats. According to a study
conducted by National Environment Engineering Research Institute (NEERI), the waste generation with respect to these ULBs in one day is as follows:

| S. No. | No. of ULBs | Particular of ULBs                  | Quantity (TPD) |
|--------|-------------|-------------------------------------|---------------|
| 1.     | 2           | Municipal Corp. (Shimla and Dharamshala) | 108.00        |
| 2.     | 31          | Municipal Councils                   | 67.95         |
| 3.     | 21          | Nagar Panchayats                     | 166.50        |

In line with the Solid Waste Management (SWM) Rule 2016, the state has a policy for SWM which has the following goals:

- 100% door to door collection.
- Segregation at Source.
- Spreading awareness for better public participation.
- To develop better treatment and disposal facilities.
- Better regulation.
- Waste minimization.

Under the SWM Policy there is a directive to collect waste which is segregated at source then transport it to nearby treatment plant. Till 2015, there was only one treatment plant at Shimla. In November 2017, there was a proposal for establishing six new solid waste management treatment plant at Baddi, Mandi, Kangra, Chamba, Sirmaur and Hamirpur respectively. The state has identified dumping sites at Shimla, Nahan, Solan, Bilaspur, Mandi, Rangri (Manali) and Keylong.

IV. USE OF IOT TO REFURBISH THE TRADITION OF WASTE MANAGEMENT

Waste management is basically a two tier system, waste collection and waste disposal. IOT provides smart technology for both these system. For efficient and smart collection of waste, sensor enabled bins (connected to a cloud network) or automation of collection routes may be implemented. For disposal, automated waste segregation and smart solution for recycling of waste can be worked out. Let us elaborate this more:

4.1. Sensor-Enabled Smart Waste Bins

With the use of radio frequency identification (RFID) and sensor technology, sensor enabled waste bins can be installed at various pre-defined places. The sensor based on sonar technology can be used. These sonar sensors can be installed at the top of the bins and they have the capability to sense measurement of 2cm to 400cm of non contact. The sensor data can be forwarded to a server using Wi-Fi network. This data can be used to forecast future waste levels for any particular site to predict the selection of filled bins to evacuate in time.
4.2. IOT for Route Automation for Waste Collection Vehicle

The data collected and forwarded by sensors from the smart waste bins is then computed to predict the optimised route for the waste collection vehicles. After this, GPS system is used and *shortest path spanning tree algorithm* is applied. This helps to decide the shortest path to collect waste from early filling waste bins. Now this data is collaborated with realtime GIS data of streets with different traffic load. The information from these parameters is then computed to automate an optimised route for the waste collection vehicle. The advantages of route automation are as follows:

- Reduction in collection cost by less of fuel and manpower cost.
- Prioritization of areas in urgent need of cleanup.
- Data for predicting future trends.

![Diagram of IOT based Route Automation for Waste Collection Vehicle]

**Figure 3. IOT based Route Automation for Waste Collection Vehicle**

4.3. Automated Waste Segregation and Smart Recycling Techniques

Waste segregation is an important aspect of waste management process. Ideally, the waste segregation should be done at source of its generation but the scenario is different. In India, this...
process mostly either done manually or not done at all. If done manually, this leads to health hazards for the people involved and this is also violation of their human rights and if segregation is not done at all then it leads to mixing of toxin and non-toxic waste which results in a major environmental endangerment. Here, IOT comes to minimized the risk by providing smart solution to segregate the waste without much of human intervention. The waste may be segregated into wet, dry and metallic waste. There are two basic technologies available which seems feasible and economical both.

(a). Sensor Based Air Blower: This may be used to segregate wet and dry waste. The waste to be segregated is put on a conveyor belt fitted with at weight sensor. The information from this sensor is send to the server which in return sends command to switch on the air blower fitted on one side of this conveyor belt. The dry waste like, paper or plastic may be blown and collected in a separate bin. The wet waste is forwarded for further disposal or treatment.

(b). Sensor Enabled Rotating Electromagnetic Arm: A rotating arm having a high electromagnetic field may be fitted over the inlet of a conveyor belt. It is a magnetic rod with metal wire coiled around it to create an electromagnetic field. The electromagnetic arm may be fitted with load sensor for minimum and maximum load, it can carry. This information is used to forward or reverse the magnetic field of this arm. When the waste comes under this arm, the metal waste containing ferrous compound gets attracted to this arm. When the weight sensor senses the maximum load on the arm, it rotates away from conveyor belt and drops the metal waste in a separate bin by reversing its electromagnetic field.
(c). Use of Smart Tags for Recycling: Recycling of waste can be done in a smart way by using QR codes, Barcodes and RFID tags. Solid waste containing these smart tags can be scanned under RFID scanner. After segregating this waste can be forwarded for recycling.

V. CHALLENGES

Though the proposed framework for smart waste management using IOT applications, is very promising but there also exist many challenges. These are as follows:

- Demographic distribution: Himachal Pradesh being a hilly state gives a challenge for waste collection and thereby source segregation of waste.
- Seasonal variation in waste generation: added tonnes of waste when tourist inflow rises.
- Less of people motivation: due to distant dumping sites, people dispose waste at any nearby site.
- Weather hindrance in internet connectivity: extreme weather conditions create a big barrier for effective internet connectivity.

VI. FUTURE SCOPE

In present time in Shimla, the volunteers of a NGO Shimla Environment, Heritage Conservation and Beautification Society (SEHAB) collects waste door to door then segregate it and finally bring it to the waste treatment plant. In return, the Shimla Municipal Corporation annually gives a grant of one crore to SEHAB. This system is functional since 2009. With better information and communication...
(ICT) support, this system can be made more efficient and cost effective. Though due to hilly terrain, door to door waste collection works effectively but there is a possibility to identify some location by roadsides. At these locations sensor enabled smart bins can be installed. The waste collected from door to door can be dumped at these smart bins. When these bins are filled up to appropriate levels then the collection vehicles may collect the waste to carry forward to the treatment plants or dumping sites. The route automation provides the shortest and fastest routes to these waste collection vehicles. In addition to citizen motivation for source segregation of waste, the treatment plants can be installed with automated segregators for wet, dry or metallic waste. After this the wastes may proceeds for dumping or recycle.

![Image of waste management system](image)

**Figure.6. Smart Waste Management through IOT application.**

**VII. CONCLUSION**

Himachal Pradesh is a home to scenic mountain towns. It has a total population of about 7.11 lakh. With 54 Urban local bodies (ULBs), it has a widespread waste management system. The load of waste varies seasonally depending on flow of domestic and international tourists. With the penetration of information technology, the waste management system also finds smart solutions. Use of IOT based applications, provides more efficient, effective and economic ways of waste management. Modern waste management strategies are based on waste reduction and waste to energy. With enhanced ICT infrastructure, the IOT based smart solutions for both these strategies can be adopted. This contributes to Swachh Bharat Mission which is intended to build clean and beautiful towns and cities in the country.

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