

INNOVATIONS IN SMART CITIES FOR WASTE MANAGEMENT - A REVIEW

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Abstract

The Planet Earth consists of various major components in order to sustain life on it. Every living creature generates waste or by-product. Waste disposal is the process of organisms returning substances back to the environment. It is anything that is purposeless or unwanted and requires disposal. Like any other process, it requires management which refers to a set of functions of organizing, planning, controlling and directing of resources. Therefore, waste management describes the procedures of the collection, conveyance, recycling or disposal and examining of waste. The entire process must be planned well, in order to avoid any discomfort or hazards to the living creatures (human/non-human). According to a study, the world generates over 2.6 trillion pounds of garbage each year. The first-ever method of waste management was documented to be in 3000 B.C. Landfills were developed and garbage was dumped and filled with dirt at various levels. Currently, Germany holds the highest standard in recycling across the world. Technology is a tool that has been repeatedly used to enhance processes. With the rise of innovations such as the Internet of Things (IoT) and smart cities, the process of waste management has become a contender for enhancement. With the World producing different types of waste, researchers are struggling to define the most suitable waste management technique. Our education system must incorporate at least some modules in this direction, to implement and find its effectiveness. This paper will explore and review different waste management techniques, methods and research work, which has been implemented in various parts of the world. Further, the paper will explore various technologies related to IoT and how it can be implemented to manage the above-mentioned issue accordingly. The researchers will provide a critical review and discussion of the techniques explored based on the findings of their study.

Keywords: Smart city, IoT for Environment, Waste Management.

1 INTRODUCTION

The term waste management describes the system of waste collection, transportation, recycling or disposal. Some of these wastes produced by human and other living beings' daily activities must be treated to avoid harmful effects on health and the environment. Moreover, waste production varies between countries around

the world, be it because of the massive population or the advancement of technologies. However, the distinction of progression between technology and waste management techniques is massive. Waste management in urban and rural areas is the municipality's overall responsibility, whereas waste produced by industries is their responsibility. With the introduction of technological development, internet advancement led to waste management innovations. The Internet has transformed the world as well as provides worldwide connectivity. Likewise, the Internet of Things (IoT) is found to support major change and outlines an evolution on the Internet is known as the Fourth Industrial Revolution. (Schwab, 2016) In earlier days, waste management techniques used to be part of non-IT studies. But these days, almost every discipline of study has taken technology-based approach for their practical implementation. For example, many civil engineering companies has started using Virtual Reality based models for showcasing their services and products. Similarly, even in the department of environment conservation along with municipality, the government of many countries are taking initiatives to enhance the services by involving various IT companies. These companies are providing many smart solutions. Hence, these days the study of the recent trends in technologies such as smart applications, Internet of Things, Artificial Intelligence etc, are needed. The educational institutions must ensure that, students are graduating with up-to-date knowledge which includes study of recent trends to prepare them to face the real time challenges.

2 LITERATURE REVIEW

2.1 Waste Management Techniques:

Living organisms produce waste, meaning it has to be managed and discarded, or hence it would occupy space and accumulate, leaving a drastic impact on the environment. Waste materials come in different states such as liquid, solid and gas. Managing waste can be done in various methods depending on the type of waste that is needed to be discarded. According to Ayhan Demirbas the methods that are used to manage waste are divided into four main methods, which are divided into sub-methods. (Demirbas,2011)

The first method is the disposal method that includes a series of sub methods integrated into it which are: source reduction, reusing and recycling the waste and turning the waste into usable energy. The Disposal methods can be used mostly with recyclable waste rather than biochemical, radioactive or hospital waste because it focuses on reusing whatever was wasted in reproduction. The second method is landfilling, which essentially is containing waste that could be harmful to people and the environment until it is degraded. Furthermore, landfilling is a rather slow process of managing waste that is divided into stages that include removal of oxygen from the contained waste, followed by treatment of the waste by the usage of bacteria, acids and other elements that aid in treating the waste. (Demirbas,2011)

The third method is Incineration. As Roopali Kukreja, explains that incineration waste management is a method that involves turning waste materials into ashes, flue gasses or heat by burning the waste or exposing the waste to extremely high temperatures. The merits of using this waste management method includes the production of power, which means this method can be used to generate a source of energy that can be used by people in many forms. (Kukreja,n.d.)

Moreover, incineration can reduce the amount of waste and is less harmful than landfilling as it is a faster and safer process given than landfills produce more toxic and explosive gasses. Given that there are a number of merits involving incineration, the demerits of incineration includes the cost of the method as it is an expensive method to be used, and even though it is less harmful than landfilling, it still produces smoke and other toxic gasses which can harm the environment.

Furthermore, it does not promote the reduction of waste or recycling which should be considered in order to reduce the harm of waste on the environment. Another kind of waste management which is used mostly with organic waste is composting, which suggests turning biodegradable waste into amendment for the soil that is used in plantations. As Adewale Matthew Taiwo mentions that this method has a more natural way of disposing and recycling waste than the other mentioned methods. However, it is not compatible with every type of waste therefore the other methods are necessary to compromise the lack of this method. (Taiwo,2011)

2.2 IoT in Waste Management

Internet of Things (IoT) is an advanced and updated cycle of the internet technology. Due to its diverse area of application and several communications and set of technologies, IoT is the key research topic to researchers in the computer science and information technology domain. IoT is a type of network that can connect on anything via internet-based protocols in information equipment sensing to conducting information communication and exchange. IoT is known to be the most promising platform that punctures the advantages of pervasive computing domains, WSN, also known as actuator networks and wireless

sensors. Researchers have identified every challenge, problems, technology standards and opportunity that have been applied in different IoT applications development.

Waste management is basically the strategy of treating solid wastes and directing a better solution to recycle things that do not belong to the waste. It disposes of the goods and substances that have been used throughout an economical and secure manner. Waste management is divided into eight major strategies that are separated into various classes. The complete classes of waste management are landfills, fermentation, composting, recycling, animal feeding, reduction with employment, burning and land application. It will also focus on the beginning of exploiting various techniques of employment and reduction. Whereas, it's to reduce the amount of unnecessary disposable materials used. IoT has the solution to oblige the utilization technique of each phase of waste management. The integration of IoT into management can be seen in the use of IoT based garbage bins in Gangnam District, Seoul, South Korea, a group of students from the University of Chung-Ang conducted a pilot of a smart bin food waste management (Zhou, IoT-Based Smart Garbage System for Efficient Food Waste Management), that test ran for a span of a year, aiming at reducing the food waste within the district by 33%. The SGB (Smart Garbage Bin) communicate with each other to check if they are full and then send data to the HSGB (Header Smart Garbage Bin), the HSGB then sends an acknowledgement to the SGBs. HSGBs communicate with each other to check if other SGBs and HSGBs are full and send the data to the Router. Once processing is completed the Router sends an acknowledgement to the HSGBs, then the Router analyzes the data and sends total SGB data directly to the Server. An incentives system was put into motion to encourage citizens to use the system, users were rewarded with currency that was calculated according to the weight of the waste deposited. Completing the pilot year, the project was found to be a success, not only did it achieve goals in the reduction of food waste, but also resulted in the reduction of energy by 16%.

The target of waste management that operates with RFID tags, ultrasonic sensors and IoT devices is to evaluate the citizen interaction with the process of waste management. Ongoing cities all over the world are targeting to be a smarter city, however, the most significant challenges that occur in the present cities is the processing of waste. where two aspects are having an impact to this challenge such as quick growth of the population and the expansion of the urban areas. A lot of costs and efforts will be saved if an investment is being involved with the citizens' interaction with the future waste management system. Countries and IoT technologies are developing and citizens need motivation to commune and use the modern updated systems in their daily lifestyle.

3 STUDIES FROM VARIOUS CONTINENTS

When we consider a short case study on Asia and Europe, some of the key observations were identified which are described below:

3.1 Asia

Taking the Asian region as an example to the point in this case, we can see the rapid economic growth within Asian countries over the past 20 years at a cost of the exploitation of natural resources and neglect the consequences that affect public health and the environment. As a result, these countries have crippled their futures of sustainability. These issues include pollution, habitat fragmentation, deforestation, urbanization, and rapid decrease in the development of agriculture and aquaculture. Since the discovery of this issue, the only implemented solution within the far south-east is macro marketing. The waste management approach that is used by most Asian countries begins with the extraction of raw materials from the natural resources, which then proceeds to design and production which are then packaged and distributed, that is then used and maintained till they are disposed of, recycled or reused. The disposed of products are incinerated and buried in a landfill, the products fit for recycling are recycled and proceed back to design and production (Modak),(Approach to Life Cycle Thinking).

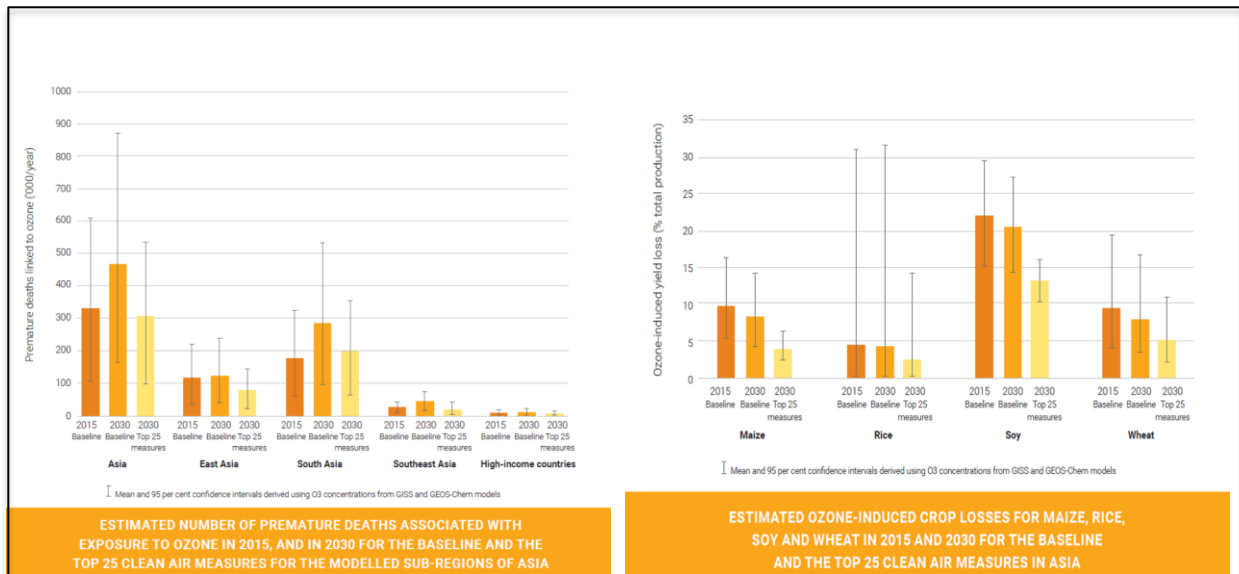


Fig 1. Air pollution measures for Asia and the Pacific (Ccacoalition.org 2015)

Fig. 1 shows a graph indicating the amount of premature deaths caused by pollution in several parts of Asia. Landing at a high of about 200,000 deaths in 2015 in Southern Asia, while a low of less than 30,000 in Southeast Asia, with an overall above 300,000 deaths across all of Asia. Estimating an increase to about 60,000 deaths in Southeast Asia by 2030, while an increase to about 300,000 deaths in South Asia, and an overall increase to 450,000 across Asia.

3.2 Europe

Within the continent of Europe, countries must follow the EU-environmental policies and laws, to ensure a healthy environment. The environmental reviews conducted by these countries aim at improving the implementation of these policies and laws by identifying the causes and obstacles that the environment faces within the European Union. These reviews were adopted in early 2017, the documented reviews are shared between members of the EU for improvement and better knowledge in improving the implementation practices. This aims to foster cooperation between public authorities and stakeholders to acquire specific solutions that are fit to address each issue. To sustain and preserve a healthy environment it is recommended to increase in environmental responsibility and decrease in negative outputs, waste recycling in the EU increased in specific countries but the recycling level was low with an average of (24.6%) in some countries such as Austria, Greece, Malta, Norway showed a decline in recycling in the past several years, however Germany was the leading country in recycling with a measurement of (65.5%) the reason behind the recycling outcome is dependent on the living situations in the country, if EU follows the waste management implementation it is estimated to result in a yearly savings of (€ 72 Billion) and an increase in the EU recycling and management estimated to (€ 42 Billion) and a creation of 400,000 jobs by 2020 (Communication From The Commission To The European).

3.3 Africa

The Africa region needs to think of new waste treatment techniques which will need a considerable amount of capital investment. This is primarily due to increase in population and hence increase in demand of smart solutions for the waste management methods. Current landfills in Africa have challenges related to this. (AureconGroup 2020) This transition would require some time and needs proper assessment and evaluation in order to move to smarter and sustainable solution. Suppliers and specialists in waste management need to collaborate to promote a collaborative approach to seeking solutions to the problems facing government. Government faces technological, political, structural, and social constraints which are not easy to resolve when considering waste management's future. (AureconGroup 2020)

4 DISCUSSION

As seen from the literature reviews above, waste management methods do differ between countries. They differ in terms of importance, methods and rates. In Europe, laws and policies regarding waste management are set up in order to maintain and ensure a safe environment, and the countries in Europe must be kept in mind and followed. The EU-environmental policies and laws were initiated according to the European environment barriers and problems. European Union has been working and adopting different waste

methods such as landfill, recycling, prevention, re-use, and energy recovery. On the other hand, Asia has grown and developed economically at a very high rate but became polluted in return. While nearly all the developed West populations have wastes hygienically managed and disposed of, which is practically far from reality in Asian economies. As for now, China is one of the countries that generate a high volume of waste, which covers 20% of the global waste trade, which is led by their woefully deficient methods in managing and disposal of wastes along with lack of the required and needed approaches of waste management. Asia needs to improve and change its waste management.

5 CONCLUSION AND RECOMMENDATIONS

After the careful consideration of several waste management techniques, alternative methods used by different countries, and the integration of technology into waste management it is apparent that most methods focus on the disposal of waste that causes pollution in a different manner. To conclude, the researchers have deduced that with present evidence, pollution is a danger to public health and on the rise, causing premature deaths, airborne diseases and the exhaustion of natural resources. Many researches have shown that the integration of IoT into waste management will be beneficial to the environment and humanity. Causing less damage to the environment and replacing natural resources at a bigger scale. The pilot showed the use of added incentives to encourage the public to recycle, showing that regulations and policies could be effective but not over incentivized recycling. Where the incentive spreads awareness faster and gives a sense of accomplishment. Furthermore, with the integration of IoT, waste management will see an upgrade in efficiency, benefits and costs.

IoT implementation in waste management can be beneficial since it could facilitate automation of various manual processes through smart applications. Whether it is related to the route management of the thrash collection, or its other processes related to recycling of waste, in every stage the smart applications of IoT can play vital role in speeding up the process with precision. This could also involve sensors installed on each bin, cloud-based data collection and synthesis, and a user interface / smart app, ISB has created a network of connected devices for effective waste management. (iotforall.com 2020)

The trial of the same could be done by means of installing virtual laboratories and process of simulations. These days, virtual laboratories are playing key role in education since they can provide remote access to the labs and doesn't require user to be present there. It is also very cost effective process of implementation for educational institutions. (Al Ajmi, Al Badai, and Naidu 2017) For every development process of IoT based smart applications, it is important to test for the effectiveness and feasibility of implementation for the locality. This is due to availability of internet connectivity. Because every smart app solely depends on internet, for which the local municipality must ensure about proper coverage of mobile signals. Hence the IT policies deployed to support such projects plays key role in the implementation on country-wide implementation. The ideal method recommended by the researchers is one that combines both policies and IoT.

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