Ceddi Journal of Information System and Technology (JST) *ISSN: 2829-808X (print)*
Vol. 3 No. 2 December (2024) *ISSN: 2829-6575 (online)*
https://doi.org/10.56134/jst.v3i2.51

Design and Development of a Smart Trash Bin to Minimize Odor from Household Waste Based on the Internet of Things

Mohd Abdul Ghaffar[1], David HL[2], Kim Leah[3], Mansyur[4]

[1]*Applied Science, Universiti Malaysia Terengganu, Terengganu, Malaysia*
[2]*Informatics Engineering, Universitas Teknologi Akba Makassar, Makassar, Indonesia*
[3]*Computer Science, Drexel University, Philadelphia, United States*
[4]*Educational Research and Evaluation, Universitas Negeri Makassar, Makassar, Indonesia*

Abstract

The problem that occurs is that household waste continues to increase along with the development of population and the number of increasingly dense settlements. The existence of this household waste is of concern to the community and the government because it can cause various negative impacts. Based on the results of observations of the existing trash cans, the accumulation of household waste is the source of this unpleasant odor. Smell is connoted as something that tends to disturb comfort, and gives the impression of being unclean and the like, such as fishy, rotten, urine, rancid, and so on. The smell of burning garbage is also dangerous because it contains H2 which reduces the amount of oxygen in the air. This study aims to prevent the occurrence of unpleasant odors from garbage. The tool will be designed using the NodeMCU microcontroller with website-based monitoring and Whatsapp notifications automatically when the trash can is full and automatic deodorizing powder spraying according to the concentration of gas released by the stench. This study uses the Experimental and Comparative Testing method in designing an IoT-based Smart Trash Bin tool and conducting tests on the built system and comparing the test results with the expected system. The results of this study indicate that the Smart Trash Bin tool can work and function as expected, namely being able to minimize the unpleasant odor emitted by the trash can and being able to monitor the sprinkling of deodorizing powder, the status of the height of the trash can and can provide notifications both automatically and manual to officers through the website.

Keywords: Smart Trash Bin; Internet of Things (IoT); MQ Sensor Integration; Household Waste; Odor Minimization.

Received: 5 December 2023 Revised: 10 February 2024 Accepted: 30 November 2024

Introduction

The Internet of Things (loT) according to ITU-T Recommendation Y.2060 is defined as an invention that is able to solve existing problems through the combination of technology and social impact (Yudhanto & Azis, 2019; Zubaidi et al., 2019). In terms of technical standardization, loT can be described as a global infrastructure to meet the information needs of society, enabling advanced services with interconnection both physically and virtually based on existing and developing information and communication technology (ICT). IoT can be implemented in various fields such as smart grids, smart homes, smart transportation, smart cities, and even in terms of waste problems (Nižetić et al., 2020; Talari et al., 2017; Ayutantri et al., 2021). IoT is needed to help humans, where based on the point of view of the system, humans are slow, error-prone objects, inefficient data carriers, and have limitations in terms of quality and quantity (Samsugi et al., 2021; Bedi et al., 2018; Mathew et al., 2018; Wang et al., 2022). As an alternative, it will be more efficient if the system can be connected to sensors that can translate events in the real world directly (Yudhanto & Azis, 2019).

One of the problems faced by modern society today is the problem of waste such as hospital waste, factory waste to household waste, in this case, the focus will be on household waste (Defitri, 2023; Ramadan, 2024; Abdel-Shafy & Mansour, 2018; Demirbas, 2011). Household waste is the residual material generated from household activities, household waste both in liquid and solid form which can pollute the soil, damage the water ecosystem, affect the community's drinking water source, cause disease seeds, and cause unpleasant odors such as food waste, vegetable waste, and plastic waste (Sunarsih, 2014; Azka, 2022; Tobing, 2018; Sutalhis et al., 2024).

*Corresponding author.
E-mail address: mohd.abdulghaffar@gmail.com (Mohd Abdul Ghaffar)

Household waste continues to grow along with the development of the population and the number of denser settlements (Administrator, 2023; Hariyani, 2021; Saraswati, 2022). The existence of this household waste has become a concern for the community and government because it can cause various negative impacts (Erika Erika & Eva Gusmira, 2024; Hasibuan, 2016b). Based on observations of existing garbage bins, the accumulation of household waste that causes unpleasant odors is increasing and is less noticed by local officials (Gangga et al., 2023; Jouhara et al., 2017; Royte, 2007). Odor is connoted as something that tends to disturb the comfort, unclean impression, and the like such as fishy smell, rotten, snotty, rancid, and so on. The smell of burning garbage is also dangerous because it contains H2 which results in reduced oxygen levels in the air (Haq et al., 2021; Utami et al., 2023; David & Kopac, 2018). Odors are gaseous chemical compounds from either liquid vapors or sublimated solids (Hermann et al., 2023). Odors can be in the form of single compounds such as H2S and NH3, or combined compounds such as the smell of air freshener or coffee which is a complex combination of 670 compounds (Admin, 2021; Yuwono, 2008). As a result, people who live around the garbage cans feel uncomfortable. Environmental pollution and damage caused by household waste disposal is not something that can be underestimated because it will later interfere with public health and comfort. Therefore, it is important to find a solution so that the problem of household waste can be overcome (Hasibuan, 2016a; Sari et al., 2021; Sunarsih, 2014a).

Some previous studies that raised the same case by Siyamsih & Andika (2019) entitled "The Effect of Garbage Odor on Communities Around the Putri Cempo Disposal Area". This study aims to determine the impact felt by the community around the Putri Cempo landfill. The results of this study indicate that the garbage odor generated from the Putri Cempo Waste Landfill greatly affects the health of the community around the Putri Cempo Waste Landfill. In addition, the trash is also a gathering place for bacteria, viruses, and something that can cause disease.

Further research by Chandra et al. (2020) entitled "Design of a Trash Height Monitoring System Using Arduino Microcontrollers and Web-Based Applications". This research makes a tool in the form of Smart Trash which focuses on monitoring the height of website-based garbage. However, the results of this research have not been able to solve the problem of unpleasant odors generated from household waste. Research by Desnanjaya et al. (2021) entitled "Portable waste-based capacity detection system using Android-based Arduino" obtained in his research produced a tool in the form of Smart Trash which focuses on monitoring the full capacity of website-based and Arduino-based trash cans in the trash can. However, the results of this research have not been able to solve the problem of unpleasant odors generated from household waste and have not been able to provide notifications to users via automatic messages regarding the condition of the trash can.

Research conducted by Saputra & Badaruddin (2020) entitled "Touchless and Automatic Notification Smart Trash bin". In his research, he produced a smart trash can that is able to detect full trash cans as well as provide automatic notifications via the Telegram platform. However, as we know in the current era, social media users are one of the needs used by the community in finding information and communicating. Releasing data from We Are Social, the social media platform most used by Indonesians in 2022 is the WhatsApp application with a percentage of 80 percent of all social media users in Indonesia, followed by the Instagram, Facebook, TikTok, and Telegram applications (Yonatan, 2024).

From the problems that have been described and some of the research above, the authors will conduct research related to the design of a smart trash bin for household waste using the Internet of Things (IoT) to prevent foul odors from the garbage. The tool will be designed using a NodeMCU microcontroller with website-based monitoring and automatic Whatsapp notifications when the trash can is full and automatic sowing of odor control powder according to the timer conditions and the height of the garbage that has been set. It is hoped that this design can solve the problem of unpleasant odors that interfere with the health and comfort of the surrounding community.

Method

The process of problem-solving consists of several stages: Monitoring, Analysis Pieces, System Design, and Experimental Comparative Testing. Monitoring involves the systematic and continuous collection and analysis of information based on pre-determined indicators to ensure that activities align with their objectives and to facilitate corrective actions when necessary (Prennushi et al., 2002; Belferik et al., 2023; Gemilang, 2023). This activity includes regular data collection to track progress and address potential issues, emphasizing its role as a routine mechanism for evaluating ongoing efforts (Ramita et al., 2020;Deri, 2023; Kumorotomo, 2021).

Analysis Pieces, on the other hand, entails a detailed examination of components to gain a deeper understanding of a subject. PIECES analysis, as described by Prayogi et al. (2021), is utilized in system development to classify issues, opportunities, and directives by evaluating five variables: Performance, Information and Data, Control and Security, Efficiency, and Service. These variables collectively enhance the system's functionality, reliability, and user satisfaction.

Following this is the System Design stage, which focuses on defining the system architecture, interfaces, and data to fulfill specific requirements. This phase ensures alignment with organizational needs through approaches such as custom development, commercial solutions, or hybrids, as outlined by Saputera & Yunita (2019).

Lastly, Experimental Comparative Testing involves comparative and experimental methods. Comparative investigations explore patterns and trends under varying conditions, while experimental investigations conduct controlled tests to establish causal relationships. This phase integrates design, testing, and evaluation, comparing actual outcomes to expected results to verify the system's effectiveness and precision (Agency, 2018).

Results and Discussion

Result

The results discussed in this study regarding the implementation of the tool made, namely the smart trash bin which is used to monitor the Internet of Things (IoT) based trash can, then testing of the tool will be carried out. The purpose of this test is to determine the accuracy and accuracy of all circuits that have been made so that deficiencies that may occur can be corrected.

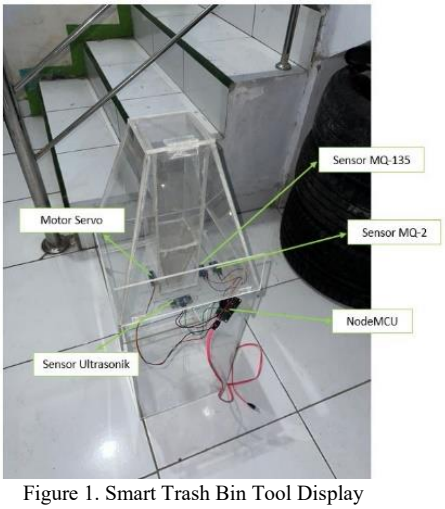

Figure 1. Smart Trash Bin Tool Display

As an essential step in ensuring the quality and reliability of hardware, hardware testing is conducted by inspecting and examining all circuits within the installed electronic components. This process aims to verify that each component operates according to its technical specifications, functions harmoniously within the system, and can optimally support the device's overall operation (Kundiharto, 2024). The testing also seeks to identify potential defects or inconsistencies that could affect the device's performance before being integrated into a larger system or deployed in a real-world environment. The hardware testing includes the following: sensor testing, servo motor testing, LED testing, and powder testing.

Sensor Testing, in the tool made, 3 sensors are used, namely ultrasonic sensors which are used as height detectors of garbage that has entered the trash can, MQ-2 sensors, MQ-135 sensors, and MQ-136 sensors as gas detection sensors. In testing the ultrasonic sensor tool, testing is carried out by giving contents to the trash can to the limit of 15cm, testing is carried out 4 times. At the same time, the sensor for gas is tested for 2 samples, namely gas testing for durian fruit

and fish beaks, where the serial monitor in the Arduino software will show the value of gas testing and ultrasonic testing. Samples and results can be seen in the following Table.

Ultrasonic Sensor Testing, this tool is used to measure how the distance between objects in front of the sensor, this ultrasonic sensor test was carried out by filling the trash can from the bottom of the tub until it was full, testing was carried out 4 times to ensure the sensor was running properly. The results of the test are in Table 1.

Table 1. Measurement of garbage height

Ultrasonic Sensor
Altitude Gain
38
23
15
6

The results obtained in Table 1 show that during the 4th test, the sensor detects a decrease, it is because the detection accuracy of the ultrasonic sensor device has detected the height of the garbage almost full. Gas Sensor Testing of Durian Odor, this tool is used to measure the concentration of gas released by durian in the trash can. This trial was conducted 3 times to find out if the sensor was running well, as can be seen in Table 2.

Table 2. Tests on durian odor

Gas Sensor	Description
100	No garbage coming in yet
200	Detected
250	Detected

From the test results of the tool against durian odor, the value of 100 is obtained for normal gas concentration, meaning that the gas concentration is generally before being exposed to waste gas. Based on testing of the MQ-2 sensor, MQ-135 sensor, and MQ-136 sensor, the value is 250 after inserting durian skin. Gas Sensor Testing of Fish Beaks, this tool is used to measure the concentration of gas released by the beak of the fish in the trash can. This test was carried out 3 times to find out if the sensor was running properly, as can be seen in Table 3.

Table 3. Test on fish beaks

Gas Sensor	Description
100	No garbage coming in yet
320	Detected
400	Detected

From the results of the tool test on fish beaks, the value of fish beak gas concentration is higher than the gas concentration value of durian. Servo Motor Testing, the servo motor functions to open and close the deodorizing powder according to the specified gas concentration range, the test on the servo motor was carried out 4 times The following accuracy The results obtained by the servo motor can be seen in Table 4.

Table 4. Servo motor testing

Gas Sensor	Description
100 - 249	Closed
250 - 600	Open

The results obtained in Table 4, show that the servo will open the deodorizing powder cover when the gas sensor range reaches 250 - 600. The LED (Light Emitting Diode) serves as an indicator light on electronic devices to display the status of whether the trash bin is full or not. A green LED indicates that the trash bin is not yet full, while a red LED indicates that the trash bin is full. The test results for the LED can be seen in Table 5.

Table 5. LED Testing

Ultrasonic Sensor Value	LED	
	Green	Red
38	✓	-
23	✓	-
15	✓	-
6	-	✓

Powder testing, odor-eliminating powder is a powder used to eliminate odors according to the specified gas concentration. then the sowing of odor-eliminating powder will automatically be sown according to the conditions that have been set. The test results regarding the dosage of powder to reduce gas concentration based on the volume of waste in the garbage can can be seen in Table 6.

Table 6. Powder sowing

Waste Volume	Powder Measure
25 %	600 gr
50 %	1200 gr
75 %	1800 gr
100 %	2400 gr

Based on Table 6, powder testing was carried out on the volume of waste with a volume of 50%. The test results can be seen in Table 7.

Table 7. Powder testing

Before	Status	After
100	No Sowing	100
180	No Sowing	180
200	No Sowing	200
>=250	Sow Successfully	180

From the results of the powder sowing test in Table 6, it is found that if the gas concentration is at the normal value of 100, the sowing is not running. Sowing was successfully carried out in the 4th test with the gas concentration value in the trash can reaching more than or equal to 250. After sowing, the gas concentration value obtained in the trash can decreased to 180. Based on this, it can be said that the deodorizing powder will reduce the unpleasant taste. The implementation of the application interface and software testing is conducted by evaluating the functionality of the software. The website interface for the smart trash bin displays the monitoring process of the trash bins connected to the website. This application also features a button for sending notifications via WhatsApp, and the notifications sent to the connected WhatsApp account can be seen in Figures 2 and 3.

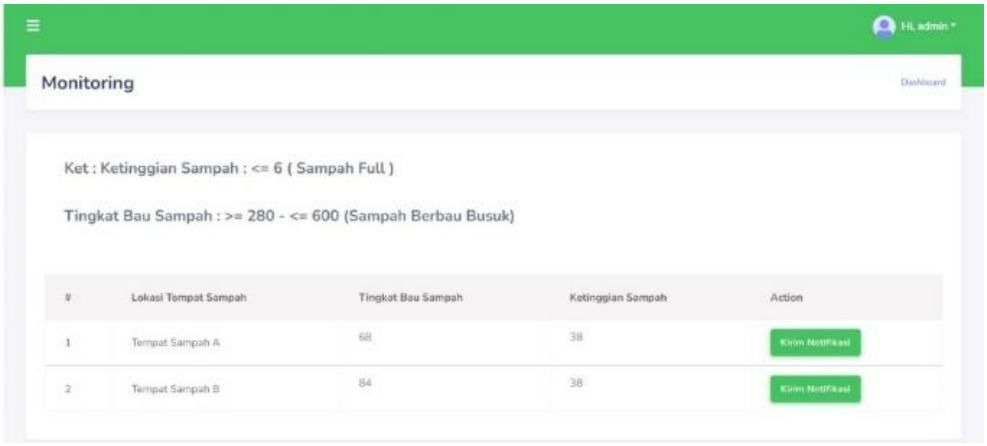

Figure 2. Trashbin application view

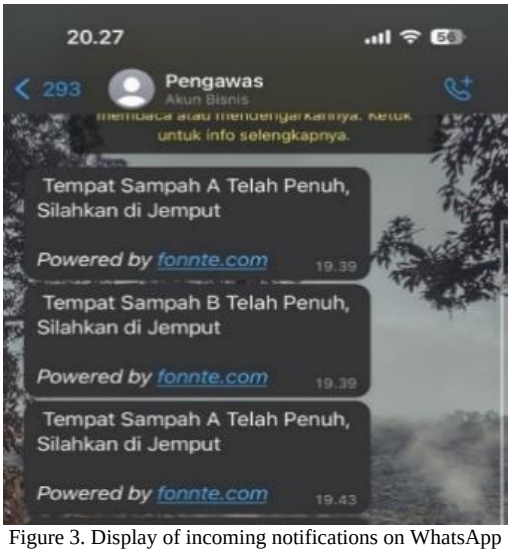

Figure 3. Display of incoming notifications on WhatsApp

Discussion

This study successfully designed and developed a Smart Trash Bin based on the Internet of Things (IoT) capable of reducing unpleasant odors from household waste. The device utilizes sensors to detect the trash height and gas concentration, sprays deodorizing powder automatically and sends notifications via WhatsApp when the trash bin is full. The test results indicate that the tool functions as expected, effectively reducing unpleasant gas concentrations and providing accurate notifications to users. This finding is significant because it offers a practical and innovative solution to the often-overlooked issue of household waste—unpleasant odors. These odors, stemming from chemical gas compounds such as H_2S and NH_3, can cause discomfort and health issues for nearby communities. By leveraging IoT technology, this tool not only enhances waste management efficiency but also fosters a cleaner and healthier environment.

The study's findings align with previous literature. For instance, research by Chandra et al. (2020), which utilized a web-based trash height monitoring system, and by Satria (2023), which focused on detecting full trash bin capacity, demonstrating the benefits of technology in waste management. However, this study introduces innovations such as the integration of automatic deodorizing powder spraying and the use of WhatsApp notifications, which are more relevant to the needs of Indonesian society, as supported by data from We Are Social 2022 regarding WhatsApp's dominance among social media users in Indonesia (Yonatan, 2024).

The decrease in gas concentrations following the spraying of deodorizing powder may also be influenced by other factors, such as ventilation around the trash bin. Nevertheless, consistent testing results under various conditions validate the claim that this system effectively reduces odors. Clinically, this study contributes to improving air quality around trash bins, directly impacting public health by reducing the risk of respiratory problems caused by exposure to harmful gas compounds. The study, however, has limitations in terms of large-scale testing. The system was tested in laboratory conditions with a limited amount of waste, necessitating further validation in more complex and dynamic environments. Additionally, the long-term effectiveness of the device in different environmental conditions should also be evaluated.

Conclusions and Suggestions

Conclusions

The IoT-based Smart Trash Bin system has been successfully designed and developed using multiple components, including ultrasonic sensors to measure the height of garbage inside the bin, MQ-2, MQ-135, and MQ-136 sensors for gas detection, and a servo motor to control the dispensing of deodorizing powder. Testing confirmed the ultrasonic sensor's ability to detect varying levels of garbage and the servo motor's effectiveness in managing deodorizer release.

The system functions as intended, minimizing foul odors and enabling real-time monitoring of garbage levels, deodorizer usage, and bin status. Notifications are provided to sanitation officers via a web interface, offering both automated and manual options to enhance operational efficiency. Utilizing the Experimental and Comparative Testing method, the research evaluated the system's hardware and software components, confirming their performance and readiness for practical implementation. This IoT-based solution demonstrates its potential to improve waste management by integrating advanced sensors and web-based monitoring capabilities.

Suggestions

This Internet of Things-based Smart Trash Bin tool is expected to be developed further to make it easier to minimize the occurrence of foul odors from garbage bins that interfere with the health and comfort of the surrounding community, and the use of monitoring applications can be further developed.

References

Abdel-Shafy, H. I., & Mansour, M. S. M. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian Journal of Petroleum*, *27*(4), 1275–1290. https://doi.org/https://doi.org/10.1016/j.ejpe.2018.07.003

Admin. (2021). *Jenis, Sumber, Bahaya dan Pencegahan Pencemaran Udara*. Kajian Pustaka.Com. https://www.kajianpustaka.com/2019/05/pencemaran-udara.html

Administrator. (2023). *Masalah Kita adalah Sampah*. Indonesia.Go.Id. https://indonesia.go.id/kategori/editorial/7714/masalah-kita-adalah-sampah?lang=1

Agency, T. E. (2018). *Scientific Reasoning - Planning Comparative and Experimental Investigations*. Texasgateway.Org. https://texasgateway.org/resource/scientific-reasoning-planning-comparative-and-experimental-investigations

Ayutantri, D. A., Irawan, J. D., & Wibowo, S. A. (2021). *Penerapan IoT (Internet of Things) Dalam Pembuatan Tempat Sampah Pintar Untuk Rumah Kos*. https://api.semanticscholar.org/CorpusID:233940272

Azka. (2022). *Mengenal Jenis-Jenis Sampah Rumah Tangga*. Tekniksipil.Id. https://tekniksipil.id/mengenal-sampah-rumah-tangga-dan-jenis-jenisnya/

Bedi, G., Venayagamoorthy, G. K., Singh, R., Brooks, R. R., & Wang, K.-C. (2018). Review of Internet of Things (IoT) in electric power and energy systems. *IEEE Internet of Things Journal*, *5*(2), 847–870. https://doi.org/https://doi.org/10.1109/JIOT.2018.2802704

Belferik, R., Andiyan, A., Zulkarnain, I., Munizu, M., Samosir, J. M., Afriyadi, H., Rusmiatmoko, D., Adhicandra, I., Syamil, A., Ichsan, M., & others. (2023). *Manajemen Proyek: Teori & Penerapannya*. PT. Sonpedia Publishing Indonesia.

Chandra, E., Sholva, Y., & Muhardi, H. (2020). *Perancangan Sistem Pemantau Ketinggian Sampah Menggunakan Mikrokontroler Arduino dan Aplikasi Berbasis Web*. *8*(1), 33–40.

David, E., & Kopac, J. (2018). Toxic compounds generated by metalworking fluids and aluminum slag landfill and their effects on environment and people. *Environmental Engineering & Management Journal (EEMJ)*, *17*(3). https://doi.org/https://doi.org/10.30638/eemj.2018.074

Defitri, M. (2023). Permasalahan Sampah Global: Tantangan dan Solusinya. *Waste4change.Com*. https://waste4change.com/blog/permasalahan-sampah-global-tantangan-dan-solusinya/

Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes. *Energy Conversion and Management*, *52*(2), 1280–1287. https://doi.org/https://doi.org/10.1016/j.enconman.2010.09.025

Deri. (2023). Monitoring: Memahami Pentingnya Pemantauan dalam Berbagai Konteks. *IdMetafora.Com*.

Desnanjaya, I. G. M. N., Nugraha, I. M. A., Sarasvananda, I. B. G., & Iswara, I. B. A. I. (2021). Portable waste based capacity detection system using Android based Arduino. *Automation & Intelligent Computing Systems (ICON-SONICS)*, 45–51. https://doi.org/https://doi.org/10.1109/ICON-SONICS53103.2021.9617000

Erika Erika, & Eva Gusmira. (2024). Analisis Dampak Limbah Sampah Rumah Tangga Terhubung Pencemaran Lingkungan Hidup. *Profit: Jurnal Manajemen, Bisnis Dan Akuntansi*, *3*(3), 90–102. https://doi.org/10.58192/profit.v3i3.2245

Gangga, M., Putri, D. A. E., & Putri, P. I. D. (2023). Edukasi Manajamen Sampah Berbasis Sumber di Banjar Pohgending, Desa Pitra. *Kaibon Abhinaya: Jurnal Pengabdian Masyarakat*.

https://api.semanticscholar.org/CorpusID:259727093

Gemilang, L. O. (2023). *Monitoring Artinya Pemantauan Secara Sistematik*. Laskarotomasi.Com. https://laskarotomasi.com/monitoring-artinya/

Haq, Z. F., Ma'rufi, I., & Ningrum, P. T. (2021). Hubungan Konsentrasi Gas Amonia (NH3) dan Hidrogen Sulfida (H2S) dengan Gangguan Pernafasan (studi pada masyarakat sekitar TPA Pakusari Kabupaten Jember). *Multidisciplinary Journal*, *4*(1), 30–38. https://doi.org/https://doi.org/10.19184/multijournal.v4i1.27474

Hariyani, A. (2021). *Keterkaitan Permasalahan Sampah dengan Banyaknya Populasi Manusia yang Berpengaruh terhadap Lingkungan di Indonesia*. Kompasiana.Com. https://www.kompasiana.com/aisyiyahhariani/60bd7433d541df5a5474cd02/keterkaitan-permasalahan-sampah-dengan-banyaknya-populasi-manusia-yang-berpengaruh-terhadap-lingkungan-di-indonesia

Hasibuan, R. (2016a). *Analisis Dampak Limbah/Sampah Rumah Tangga Terhadap Pencemaran Lingkungan Hidup*. https://api.semanticscholar.org/CorpusID:188090734

Hasibuan, R. (2016b). Analisis Dampak Limbah Sampah Rumah Tangga. *Jurnal Ilmiah Advokasi*, *04*, 42–52.

Hermann, C. K. F., Morrill, T. C., Shriner, R. L., & Fuson, R. C. (2023). *The Systematic Identification of Organic Compounds*. John Wiley \& Sons.

Jouhara, H., Czajczyńska, D., Ghazal, H., Krzyżyńska, R., Anguilano, L., Reynolds, A. J., & Spencer, N. (2017). Municipal waste management systems for domestic use. *Energy*, *139*, 485–506. https://doi.org/https://doi.org/10.1016/j.energy.2017.07.162

Kumorotomo, W. (2021). *Konsep Dasar Pemantauan dan Evaluasi*. Magister Administrasi Publik Universitas Gadjah Mada. https://kumoro.staff.ugm.ac.id/wp-content/uploads/2007/07/konsep-dasar-pemantauan-dan-evaluasi.pdf

Kundiharto. (2024). *Metode Pengujian: Memahami Pentingnya dan Berbagai Tekniknya*. Alatest.Com. https://alat-test.com/blog/metode-pengujian/

Mathew, P. S., Pillai, A. S., & Palade, V. (2018). Applications of IoT in healthcare. *Cognitive Computing for Big Data Systems Over IoT: Frameworks, Tools and Applications*, 263–288. https://doi.org/https://doi.org/10.1007/978-3-319-70688-7_11

Nižetić, S., Šolić, P., Gonzalez-De, D. L.-I., Patrono, L., & others. (2020). Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future. *Journal of Cleaner Production*, *274*, 122877. https://doi.org/https://doi.org/10.1016/j.jclepro.2020.122877

Prayogi, R., Ramanda, K., Budihartanti, C., & Rusman, A. (2021). Penerapan Metode PIECES Framework Dalam Analisis dan Evaluasi Aplikasi M-BCA. *Jurnal Infortech*, *3*(1), 7–12.

Prennushi, G., Rubio, G., & Subbarao, K. (2002). Monitoring and evaluation. *A Sourcebook for Poverty Reduction Strategies*, 107–130.

Ramadan, F. (2024). *Masalah Sampah di Indonesia : Tantangan dan Solusi*. Opinia.Id. https://opinia.id/post/artikel/opini/masalah-sampah-di-indonesia-tantangan-dan-solusi-377318

Ramita, C., Ariyanti, I., & Novianti, L. (2020). Retracted Article: Aplikasi Monitoring dan Pengaduan Inventaris Barang pada Jurusan Manajemen Informatika Berbasis Website. *Jurnal Sistem Informasi (JASISFO)*, *1*(2).

Royte, E. (2007). *Garbage land: On the secret trail of trash*. Hachette UK.

Samsugi, S., Damayanti, D., Nurkholis, A., Permatasari, B., Nugroho, A. C., & Prasetyo, A. B. (2021). *Internet Of Things Untuk Peningkatan Pengetahuan Teknologi Bagi Siswa*. https://api.semanticscholar.org/CorpusID:244251392

Saputera, S. A., & Yunita, E. (2019). Desain Sistem Edutaiment Berbasis Web di Sekolah Menengah Atas. *Journal Scientific and Applied Informatics*, *2*(2), 177–184. https://doi.org/https://doi.org/10.36085/jsai.v2i2.343

Saputra, A. S. D., & Badaruddin, B. (2020). Touchless and Automatic Notification Smart Trashbin. *Jurnal Teknologi Elektro*, *11*(1), 11–15. https://doi.org/https://doi.org/10.22441/jte.2020.v11i1.002

Saraswati, A. W. (2022). Ancaman Masalah Sampah di Indonesia. *Greeneration.Org*. https://greeneration.org/publication/green-info/ancaman-masalah-sampah-di-indonesia/

Sari, N., Amrina, D. H., & Rahmah, N. A. (2021). Kajian Dampak Sampah Rumah Tangga Terhadap Lingkungan Dan Perekonomian Bagi Masyarakat Kecamatan Sukarame Kota Bandar Lampung Berdasarkan Perspektif Islam. *Holistic Journal of Management Research*. https://api.semanticscholar.org/CorpusID:250206153

Satria, D. (2023). Perancangan Tempat Sampah Otomatis Dengan Sistem Monitoring Ketinggian Sampah Berbasis Web. *Jurnal Mosfet*, *3*(2), 1–4. https://doi.org/https://doi.org/10.31850/jmosfet.v3i2.2452

Siyamsih, N., & Andika, S. nindi. (2019). *Pengaruh Bau Sampah Terhadap Masyarakat Di Sekitar Kawasan*

Pembuangan Putri Cempo. https://doi.org/10.31219/OSF.IO/ZDXHV

Sunarsih, E. (2014a). *Konsep Pengolahan Limbah Rumah Tangga Dalam Upaya Pencegahan Pencemaran Lingkungan*. https://api.semanticscholar.org/CorpusID:195550097

Sunarsih, E. (2014b). Konsep Pengolahan Limbah Rumah Tangga Dalam Upaya Pencegahan Pencemaran Lingkungan Concept of Household Waste in Environmental Pollution Prevention Efforts. *Jurnal Ilmu Kesehatan Masyarakat*, *5*(3), 162–167. http://ejournal.fkm.unsri.ac.id/index.php/jikm/article/view/158

Sutalhis, M., Nursiwan, Novaria, E., Prov, B., Selatan, S., Tinggi, S., Sosial, I.-I., Indonesia, P. C., Kunci, K., Manajemen, Rumah, S., yang Tangga, P., & berkepentingan. (2024). Analisis Manajemen Sampah Rumah Tangga di Indonesia. *CENDEKIA: Jurnal Ilmu Pengetahuan*. https://api.semanticscholar.org/CorpusID:269406038

Talari, S., Shafie-Khah, M., Siano, P., Loia, V., Tommasetti, A., & Catalão, J. P. S. (2017). A review of smart cities based on the internet of things concept. *Energies*, *10*(4), 421. https://doi.org/https://doi.org/10.3390/en10040421

Tobing, M. Y. (2018). *Pengaruh Limbah Rumah Tangga bagi Lingkungan*. Dislhk.Badungkab.Go.Id. https://dislhk.badungkab.go.id/artikel/17899-pengaruh-limbah-rumah-tangga-bagi-lingkungan

Utami, A. P., Pane, N. N. A., & Hasibuan, A. (2023). Analisis dampak limbah/sampah rumah tangga terhadap pencemaran lingkungan hidup. *Cross-Border*, *6*(2), 1107–1112.

Wang, K., Khoo, K. S., Leong, H. Y., Nagarajan, D., Chew, K. W., Ting, H. Y., Selvarajoo, A., Chang, J.-S., & Show, P. L. (2022). How does the Internet of Things (IoT) help in microalgae biorefinery? *Biotechnology Advances*, *54*, 107819. https://doi.org/https://doi.org/10.1016/j.biotechadv.2021.107819

Yonatan, A. Z. (2024). *10 Media Sosial dengan Pengguna Terbanyak 2024 - GoodStats Data*. Data.Goodstats,Id. https://data.goodstats.id/statistic/10-media-sosial-dengan-pengguna-terbanyak-2024-CaJT1

Yudhanto, Y., & Azis, A. (2019). *Pengantar Teknologi Internet of Things (IoT)*. UNSPress.

Yuwono, A. S. (2008). Kuantifikasi bau dan polusi bau di Indonesia. *Jurnal Purifikasi*, *9*(2), 175–186. https://www.researchgate.net/profile/Arief-Yuwono/publication/303821490_Kuantifikasi_Bau_dan_Polusi_Bau_di_Indonesia_Odour_Quantification_and_Odour_Pollution_in_Indonesia/links/575639be08ae0405a5758339/Kuantifikasi-Bau-dan-Polusi-Bau-di-Indonesia-Odour-Qu

Zubaidi, A., Wijaya, I., Irmawati, B., & Arimbawa, I. W. A. (2019). Pengenalan Teknologi Internet Of Things (Iot) Untuk Menyelesaikan Permasalahan Di Sekitar Bagi Siswa-Siswi Sekolah Menengah Atas Negeri 7 Mataram. *Abdi Insani*. https://api.semanticscholar.org/CorpusID:192643558