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Trash Tech Central

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ABSTRACT

This paper discusses the application of pervasive computing technology to monitor the movement of waste through Seattle's waste management system. 2,000 small, smart, location-aware tags were placed on various types of waste and tracked as they moved through the city's waste disposal process. The data was used to estimate the efficiency of the waste management system, which the authors term the "removal chain". The following are the major findings of the study:

• More than 95% of the tracked items reached compliant end destinations.

•Special waste categories, such as cell phones, e-waste, and household hazardous waste, gave rise to concern regarding adherence to best practices.

• Geographical differences were found in waste disposal practices, with trash from Bellevue and Redmond showing less compliance with recommended guidelines.

This research epitomizes how the pervasive computing technologies can be used to enhance waste management systems through providing detailed information on trash flows. This information may be helpful for policymakers and service providers in developing more effective and sustainable ways of managing waste. This kind of data can also raise public awareness about the journey of waste, with encouragement toward responsible consumption and disposal habits.

I. INTRODUCTION

The world is facing a growing environmental crisis. Both the amount of pollution that occurs regularly and the impact on the world Understanding the pollution problem is essential for developing sustainable solutions. Although traditional data sources provide insights into the amount of waste processed at a job site, But it cannot track the complex waste flows between industries. and across sites and geographic boundaries. The "Trash Tech" project is a collaboration between MIT's SENSEable City Lab and partners. It aims to bridge this knowledge gap by using ubiquitous computing technology to track landfill behaviour and pollution systems. Inspired by the NYC Green Initiative, this pioneering project leverages sensor networks and GPS tracking to Give clarification about "Production chain" pollution that is often overlooked Where we share how to understand the "yield" of a product. Trash Tech is located in Seattle. which has a small tag Thousands of intelligent and location-aware devices are attached to various types of garbage. It allows researchers to track their journey through the city's waste management system in various ways. Real-world use of these technologies aims to achieve the following goals:

- Revealing the challenges of waste management and promoting sustainability.
- Increase transparency in the waste disposal chain. Revealing the process of getting rid of everyday items.
- Identify potential inefficiencies in actual disposal systems.
- Encourage and promote behaviour change, reducing the "out of sight, out of sight" attitude related to sleep.
- Provides valuable information to policy makers and service providers to make informed decisions. Improving the design and management of waste systems and allows for real-time problem solving.

By clarifying the hidden paths of waste, Trash Tech seeks to promote a deeper understanding of the waste management ecosystem. Empower stakeholders with actionable insights and ultimately lead to a more sustainable future.

II. METHODOLOGY

The Tech Central Trash Project uses cutting-edge technology to monitor waste disposal systems in innovative ways. Increase awareness of the environmental impacts of these two types of waste. This methodology details the development and implementation of location-recognition-enabled tags for modern discarded object tracking through Seattle's waste management system.

A. Trash Tech Central Project:

- Developed by MIT's SENSEable City Lab in collaboration with partners. The project aims to explore the complexities of waste management and promote sustainability.
- Inspired by the New York Green Initiative, with a focus on understanding The waste "disposal chain" is similar to "Supply chain" of produce • Use thousands of small, intelligent, location-aware tags to attach to waste materials. and are inspected when passing through the city's waste management system.
- Based on previous SENSEable City Lab research into the use of sensors and mobile technology to analyze and understand cities.

B. Data Acquisition:

1. **Tracking Device:**
   - First-generation tags: Employed GSM cellular phone technology and estimated position using Cell-ID triangulation, offering robustness even within buildings or trash piles.
     - Key components included an orientation sensor, microcontroller, EEPROM, antenna, GSM modem, sim card, and battery.
   - Second-generation tags: Combined GPS and CDMA cell-tower trilateration, utilizing Qualcomm's gpsOne technology for accuracy and availability.
     - Features included a chipset, memory, vibration sensor, GPS, CDMA capabilities, and a battery.
   - Duty Cycling Algorithm: Ensured extended battery life, allowing tags to track trash to its final destination.
     - Incorporated hibernation mode activated by an accelerometer when no movement was detected.
   - Orientation sensors: Monitored location changes and increased location sampling rate during movement or when new cell tower IDs were detected.
   - RoHS Compliance: All tag components met U.S. and EU standards for electronic products, ensuring safe introduction into waste streams.
2. **Trash Tag Deployment:**
   - Tag selection: Embedded 1,977 Trash tags, with 1,152 traces used in the analysis after dice cleaning. o Different types of waste: Items are selected based on material, technology, size and functionality.
   - Tagging and Protection: These tagging foams attach to objects and are protected with a layer of shock-absorbing insulating foam.
   - Metadata Collection: recorded sources of disposal, labelling, specifications, and waste types.
   - Various disposal methods: Forum uses different disposal locations and formats. or implementation in Seattle: implemented for more than six months It involves researchers, volunteers and participants from families and schools.
   - Record Information: For recorded material properties, photographs, disposal schedules and locations. as well as real-time tracking information

C. Data Processing and Analysis:

- Data from the embedded tag is sent to the antenna. Collected by mobile phone service providers. and sent to the SENSEable City Lab server at MIT.
- Data Cleanup: The form has removed reports of incorrect translations and short traces. This can be caused by blocking the signal or the sensor being damaged.
- Visual inspection: Eliminate traces of items not entering the waste disposal system.
- Resulting dataset: 1,152 tracking forums were extracted for analysis. This is equivalent to 2 items of sludge per day passing through the waste management system.

With meticulous design and implementation of this method The Tech Central Trash Project aims to create an open dataset that will reveal insights into the trends and performance of Seattle's waste management system.

III. MODELING AND ANALYSIS

The Trash Tech Central Project uses large datasets collected from two garbage collection tracks to analyse and model the performance of Seattle's garbage disposal chain. which involves classification of waste Specifying the origin and destination and evaluating system performance against best practices and contractual obligations.

A. Trash Categorization:

To facilitate analysis Therefore, 11 types of waste are created according to the disposal mechanism, material volume and expected indefinite fate of life:

- Cell phones:
- E-waste: (computer equipment, household electronics)
- Glass: (bottles, jars, tableware)
- Household hazardous waste (HHW): (fluorescent bulbs, batteries, etc.)
- Metals: (aluminium, steel cans, scrap metal)
- Mixed: (various materials for regular disposal)
- Paper: (plain paper, card, cardboard, periodicals, books)
- Plastic Bottles: (HDPE and PET bottles)
- Other Plastic: (polypropylene, polystyrene, PVC, etc.)
- Plastic-coated paper: (milk cartons, coated paper cups, Tetra Paks)
- Textiles: (clothing and textile home goods)

B. Origins:

- The disposal site is divided into 12 areas based on physical address and designated signage locations.
- Concentrated disposal sites have been observed in downtown Seattle. It reflects the operational centre of the project.
- Coverage includes neighbourhoods such as Redmond, Bellevue and Issaquah.

C. Destinations:

- The majority of tagged trash items ended up in Seattle and nearby areas, as identified through reported locations.

- Some items travelled further, reaching destinations across the U.S. in states like California, Florida, Georgia, Idaho, Ohio, Tennessee, and Texas.
- 1,152 tagged items reached 110 distinct destinations, categorized into five groups based on the type of end-of-life treatment:
  1. Landfill: For permanent waste disposal.
  2. Recycling: For handling household recyclables.
  3. Special: For waste outside the municipal system (e.g., drop-off centres, manufacturer-owned facilities, specialty recyclers).
  4. Transfer: For temporary storage of waste and recycling before further processing.
  5. Transit: Locations along common freight transit routes or shipping centres.
- End locations were determined through a semi-automatic map matching process:
  - Location reports were compared to a database of waste facilities maintained by the US Environmental Protection Agency (EPA).
  - Results were manually verified using online maps and business directories.

D. Destination Analysis by Trash Category and Disposal Area:

- Analysis reveals different patterns in the final destinations of different types of liquor. and distribution area
- Glass, metal, paper and plastic products are mainly stopped at recycling plants.
- HHW and e-waste are greatly affected by special facilities.
- The Messages, Miscellaneous, and Mobile phone lists show a more random distribution of the two types of destinations.
- Observed patterns of geographic change:
  - A significant chunk of Southeastern Seattle liquor ends up in landfills.
  - Contrast that with the Redmond area. which does not send waste to landfill South Seattle and Bellevue are the groups that use the specialty amenities the most.

E. Efficiency of Removal Chain:

The objective of this project is to evaluate the effectiveness of a fall management system. By evaluating whether decisions are made when the intended goals are reached or not. Consider two display formats:

1. **Best Practices**:
   - sThe City of Seattle's Guide to Best Practices for Disposal and Recycling is used as a benchmark.
   - Each snack component should be categorized as:
     - Good: Meeting best practices.
     - Fair: Acceptable practices.
     - Bad: Neither best nor acceptable practices.
   - Results:
     - Over 95% of trash reached appropriate facilities, indicating a generally efficient system.
     - Concerns were raised regarding the compliance of Cell phones, E-waste, and HHW items with best practices guidelines.
     - Trash from Bellevue and Redmond exhibited lower adherence to recommended practices.
2. **Contracts:**
   - Contracts between the City of Seattle and waste management companies specifying designated facilities for different disposal areas and waste types were analyzed .
   - Results:
     - Less than 10% of trash reached the facilities specified in the contracts.
     - Trash from Issaquah and Redmond showed higher compliance with contract destinations.

- The findings suggest that the designated facilities in the contracts may not align with the most appropriate destinations based on actual waste flows.

F. Additional Observations:

- Based on observed halting and speeds of labelled goods, the methods of conveyance were approximated.
- Discardable products like paper, plastic, and electronic waste probably got shipped from Seattle's port, with reports from Vancouver, Canada, heading to the Pacific.
- Waste getting sorted for the Columbia Ridge Landfill happens by train, as part of Seattle's waste management contracts.
- Air transport is common for electronic and household hazardous waste (HHW), mainly because couriers collect return items.

Overall, The Tech Central trash project demonstrates the value of general computing technology in gaining insight into the complexity of waste management systems. to join the search Researchers will be able to identify patterns. Evaluate performance and highlight issues that need improvement This contributes to the development of more sustainable waste management practices.

IV. RESULTS AND DISCUSSION

The Trash Tech Central project, using distributed computing technology It provides valuable information about waste movement in Seattle's waste management system. Analysis of the two collected dice revealed patterns, performance, and interesting areas for performance improvement.

Effect of Reaction Time

Productivity of fatty acid methyl ester (FAME), which is the main component of biodiesel. It increases with the reaction time during the transesterification process, increasing significantly from 20 min to 35 min, with the yield increasing to approximately 5.2% after 35 min. This increase There are very few. This indicates that equilibrium reaction These findings suggest that a reaction time of 35 min is ideal for maximizing FAME yield and biodiesel quality.

Effect of Methanol to Dry Algal Biomass Ratio

The ratio of methanol to dry algal biomass plays an important role in the conversion efficiency of the transesterification reaction. Increasing the ratio from 3:1 to 3.4:1 results in a significant increase in FAME's returns, that is, a new increase beyond 3.4:1 results in a gradual decrease in conversation efficiency. Therefore, a methanol to dry seaweed biomass ratio of 3.4:1 was determined to be the most effective for the experimental process.

Effect of Catalyst Loading

Amount of catalyst used (Sulfuric acid, H_2SO_4) significantly affected the reaction taxa and FAME yield. The highest conversion efficiency (5.2%) was achieved with a catalyst to dry biomass ratio of 0.6:1. A lower ratio results in an incomplete reaction and a lower reputation theory. On the other hand, a higher ratio leads to the formation of an emulsion. increased viscosity and gel formation which negatively affects the process These results indicate that a catalyst loading of 0.6:1 is ideal for maximizing biodiesel production.

FAMEs Analysis

Analysis of FAME components in the produced biodiesel showed an abundance of methyl esters of octadecatrienoic acid (C18:3), hexadecanoic acid (C16:2), and octadecadienoic acid (C18:2). These three methyl esters accounted for 77% of the total FAME, indicating the popularity of biodiesel produced by microalgae compared to biodiesel methods. Extraction and transesterification.

Destination Analysis

Analysis of the 1,152 tracked trash items revealed distinct patterns in their final destinations:

- Recycling Dominates: the majority of waste from various disposal points Ends up at a recycling plant.
- Landfills and Transit: Landfills and transit facilities received the second-largest portion of the waste.
- Special Facilities: Large amounts of hazardous household waste (HW) and electronic waste are sent to special facilities. Emphasis is placed on proper management of these wastes.
- Geographic Variations: Waste disposal patterns vary according to geography. Southeast Seattle sends a significant share to sanitary landfills. While Redmond doesn't ship at all, South Seattle and Bellevue depend heavily on extra facilities.

Efficiency Evaluation

The efficiency of the removal chain was evaluated from two perspectives:

1. Best Practices Compliance: More than 95% of liquor items met the City of Seattle's best practices as facilities deem appropriate, while concerns were also raised regarding telephones. Move electronic waste and household waste Partly not following the recommended guidelines, the Bellevue and Redmond lines also offered little clearance.
2. Contractual Compliance: Worryingly, less than 10% of the items tracked to the location specified in the contract between the city of Seattle and the waste management company. This discrepancy indicates potential inefficiencies or outdated information in existing contracts. Issaquah and Redmond Demonstrate greater compliance with the destination specified by the contract.

Transportation Modes

Analysis of reported stops and velocities of tagged items provided insights into transportation modes:

- Recyclables : Recyclables, including paper, plastic and electronic waste, may depart from the Port of Seattle, pass through the Port of Vancouver and transit the Pacific Ocean.
- Landfill Waste: Waste transported to the Columbia Ridge Landfill is transported primarily by rail, subject to Seattle's waste transportation agreement.
- E-waste and HHW: Air transport is mainly electrical and household waste, which may be related to the Curie service used in the recycling process.

Implications for Waste Management

The Trash Tech Central project initiative highlights the potential of a wide range of technologies to change the way we understand and manage waste. Being able to track waste throughout its entire disposal process provides valuable information:

- Informing Policymakers and Service Providers: Detailed information on waste streams can inform policy decisions and optimize waste management systems to Improve efficiency and sustainability.
- Promoting Public Awareness: Seeing the journey of waste can increase public awareness of the impact of waste, encourage responsible use and disposal habits, and reduce the "out of sight, out of mind" mentality.

The study's findings highlight the need to address specific challenges:

- Improving HHW Disposal: Proper urban solid waste disposal through suitable educational programs is the need to fulfill regulations and reduce environmental hazards.
- Revising Waste Contracts: an inspection of waste contracts is a must to make sure that the best practices for the disposal and flow are being followed even if there are variations from the contracts about the destination of the waste.

Technology has allowed us to have a closer look at trash management, as indicated by the Tech Central trash project. And it becomes the key to more sustainable futures through data solutions.

V. CONCLUSION

Tech Central trash project in Seattle, which employs general processing along with the waste management of which it exhibits the technology that can help to peer into the wasted cycles and thus pave the way for improvement while talking about the possible motivations and desired results. This project provides valuable conclusions regarding biodiesel production from microalgae and waste tracking through urban waste disposal systems:

Biodiesel Production:

- Because microalgae have the potential to be a sustainable feedstock for biodiesel production by extraction-transesterification methods.
- Optimization is fundamental: Experiments reveal optimum conditions for maximizing biodiesel yield and quality. This included a reaction time of 35 min, a methanol to dry biomass ratio of 3.4:1, and a catalyst loading of 0.3 6:1.
- FAME composition: The presence of prominent methyl esters of particular acids (C18:3, C16:2 and C18:2) also supports the suitability of microalgae for bio production. Diesel as well production.

Waste Tracking:

- Revealing the "Removal Chain": A search of nearly 2,000 spirits reveals complex travel patterns and distances. Revealing the complexity of waste management systems.
- High compliance with best practices: More than 95% of tracked items promoted to reach destinations consistent with City of Seattle waste disposal best practices.
- Contractual discrepancy: A relatively low percentage of items go to the location specified in the contract between the city and the waste management company. It highlights potential inefficiencies or outdated data that need to be taken care of.
- Specific areas for improvement: The study identified specific areas for improvement. This includes educating the public more about garbage disposal in the city. and reevaluating existing contracts to ensure they reflect best practices and actual waste flows.

Overall Impact and Future Directions:

- Data-driven waste management: The Tech Central trash project serves as a compelling example of how technology can transform waste management from a broadly opaque system into one driven by data and insights.
- Promote transparency and accountability: by exposing often-hidden lies. This project promotes greater transparency and accountability in the waste management system. Empowering both policymakers and service providers to make informed decisions.
- Public engagement and behaviour change: Visualizing binge drinking days can help individuals make more informed and sustainable consumption and disposal choices. By avoiding the "farsightedness" mentality.

The Tech Central Trash Project gives us a powerful message: by harnessing the power of technology. We can create a future where waste management is not just about disposal. But it's also about optimizing resource recovery. Reduce environmental impact and promote a sustainable relationship between the leader's consumption and disposability.

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