Design Project - SIE 2018

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Using GPS data to optimize zonal municipal waste collection

Methodology development and application in Chiclayo municipality, Peru.

Abstract. A replicable method has been developed to **extract** collection times from GPS data, **quantify** the optimization potential and **design** more adequate waste collection zones. Building a transfer station where waste collection trucks will transship their waste into bigger trucks will save time and money for Chiclayo municipality. By applying the method to the actual collection plan dividing the city in 33 zones, the cost considering waste collection is reduced by two and the spared time allows the municipality to get involved in other activities as markets or public spaces cleaning or recycling.

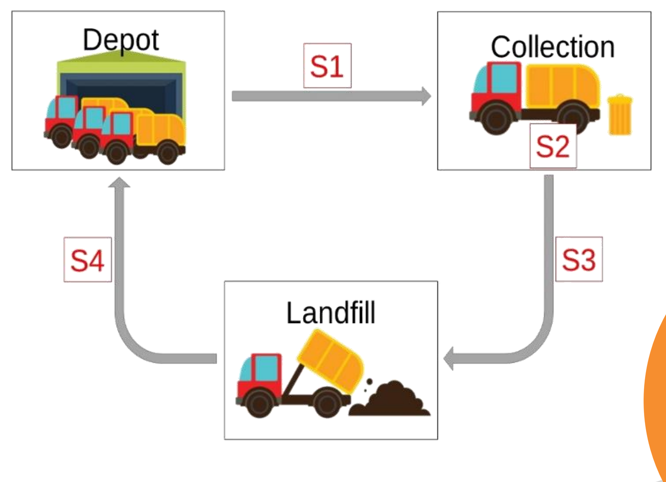
Introduction

Collaboration between the consulting company CSD engineers and the municipality of Chiclayo, has led to an improved waste collection by better management of human and material resources. Since waste is disposed without specific bins locations, a zonal approach was chosen. The city waste collection system is divided into 33 zones collected daily in three shifts. To have a better understanding of the situation, GPS data has been extracted.

Objectives

1. **Suggest** a method valid in other contexts.
2. **Use** the method to **understand** the actual collection process.
3. **Optimize** waste collection considering the actual situation.
4. **Provide recommendations** adapted to the future collection system.

Actual waste collection system (4 sub-cycles)



Methodology

Treatment:
- Matlab/Octave code
- Per sub-cycle (S1 to S4 and T1 to T4) and per zone

Input:
- GPS data per vehicle (time, position, cumulated distance)
- Map of collection zones

Optimization:
- Baseline identification
- Zones optimization considering :
  - Actual system
  - Transfer plant

Results

Baseline identification

- **No significant difference** in waste collection times **between the shifts**, but an **improvement margin between the zones**
- Waste collection cost in Chiclayo is into the upper limit compared to developping countries: 240 [PEN/ton of waste]

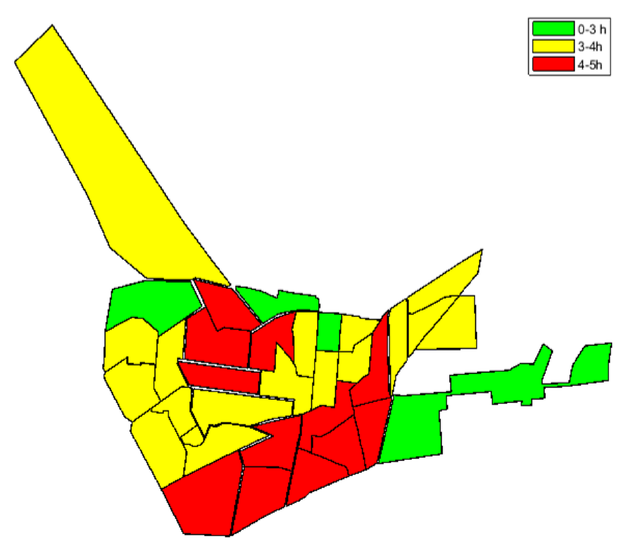
Baseline per cycle

Distance [km]	Time [h]	Velocity [km/h]	Cost [PEN/ton]
80-90	5-6	12-17	230-250

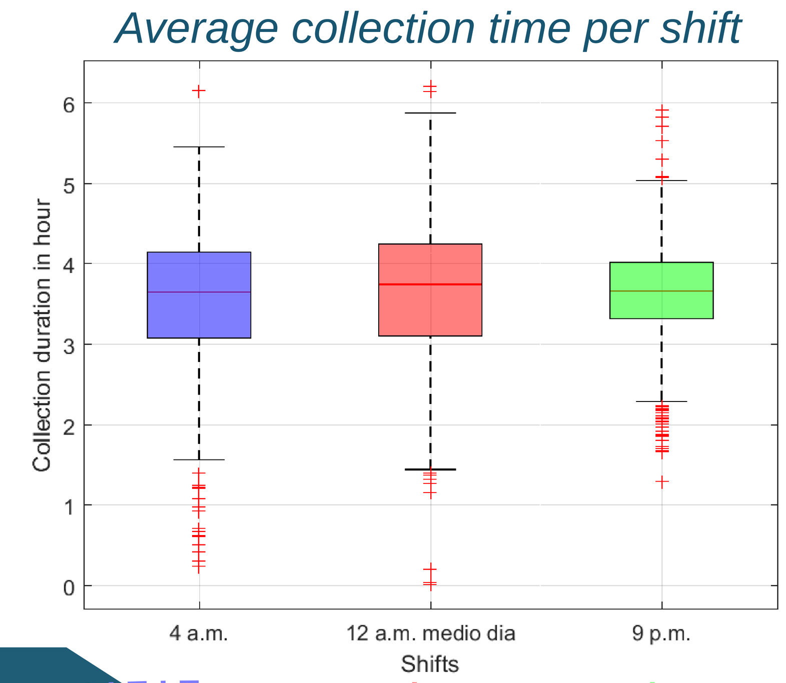
Time per sub-cycle

S2 [h]	S1 [h]	S3 [h]	S4 [h]
0.2 ± 0.7	0.4 ± 0.2	0.7 ± 0.2	0.8 ± 0.2

Waste collection times per zone



Average collection time per shift



Short-term optimization

- The zones that were not well collected or with low collection times were merged.

Lower collection times & Zones incorrectly collected

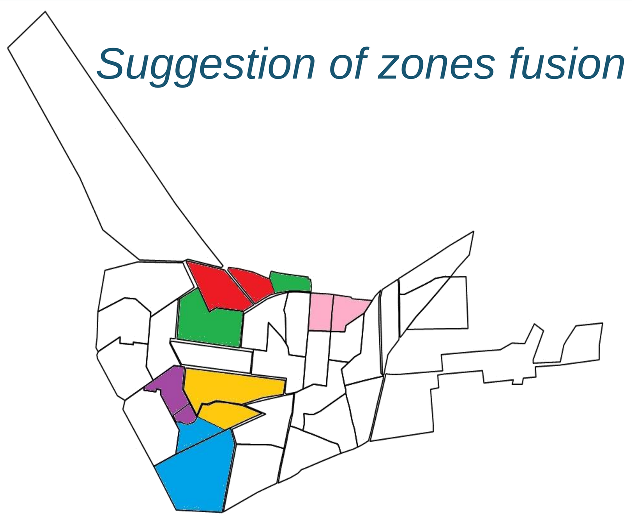
↓

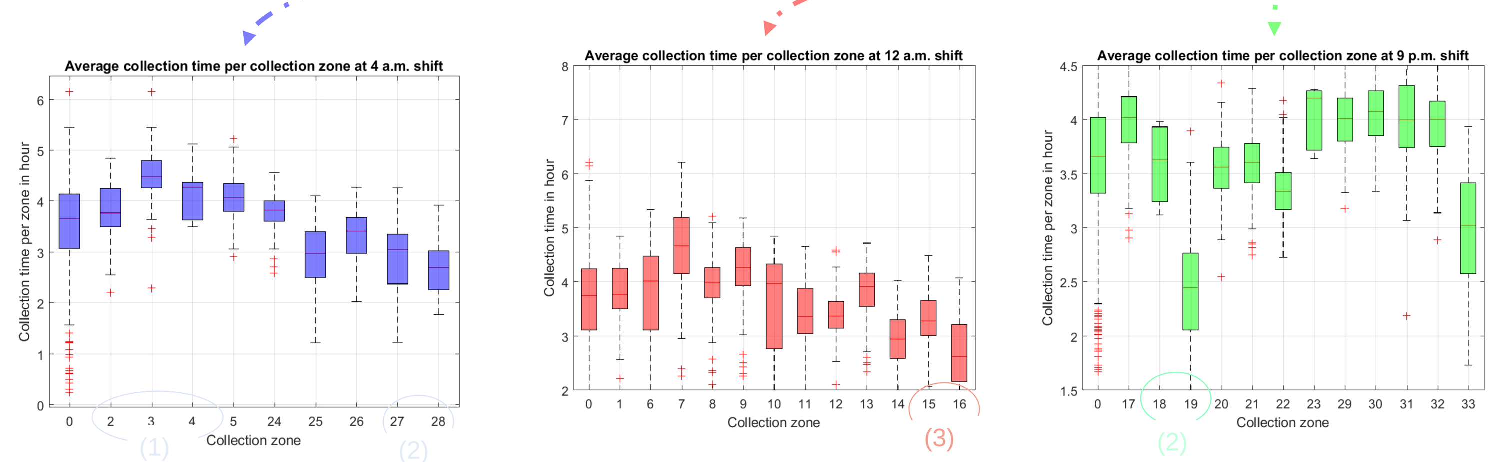
Possible fusion of zones

↓

4 collection vehicles potentially saved per day

Suggestion of zones fusion

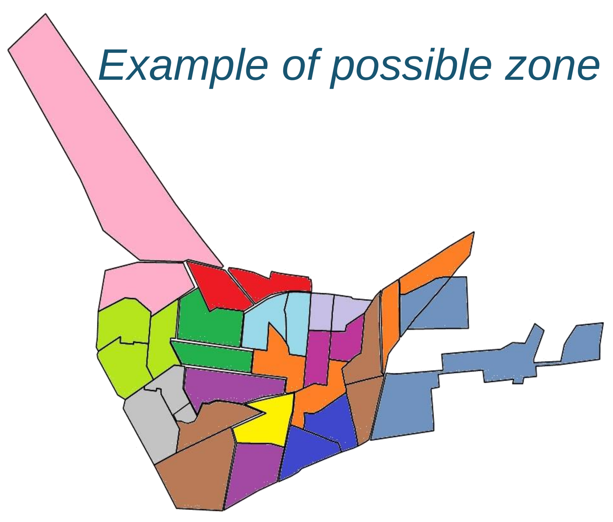




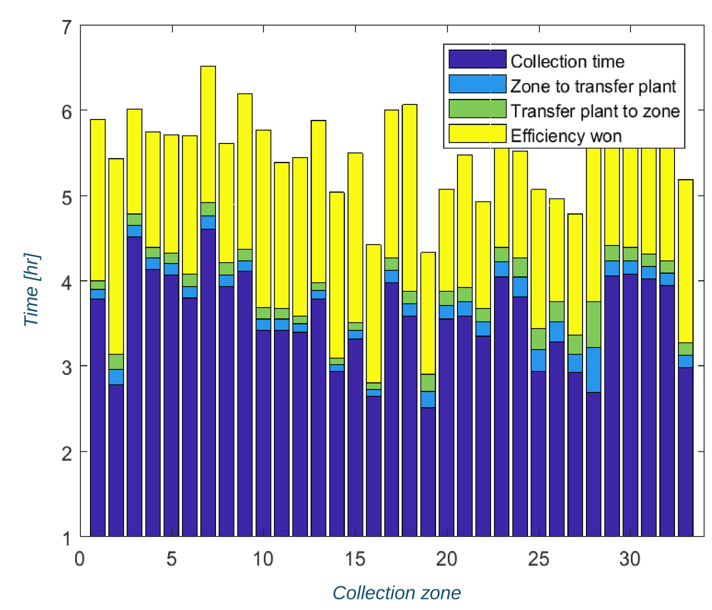
Proposition of post-transfer plant optimization

Building the transfer plant
- Reduces cycle distance by ~40 km
- Decreases collection cost and total duration by 50 %.
- Represents an efficiency opportunity (*efficiency won compared to actual cycle).*

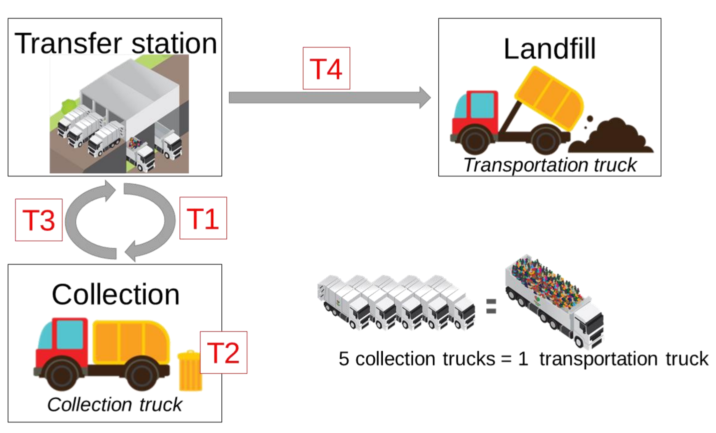
Example of possible zone fusions



Waste collection duration per sub-cycle



Future waste collection system (4 sub-cycles)



Baseline based optimization

Distance [km]	Time [h]	Velocity [km/h]	Cost [PEN/ton]
80-90	5-6	12-17	230-250

New sub-cycles

T1 (=T3) [h]	T2 (=S2) [h]	Potential time saving per cycle [h]
0.2 ± 0.1	3.6 ± 0.7	1.6 ± 0.3

Conclusion

The efficiency won compared to the actual situation can be used to adapt the collection system. This approach suggests to decrease the number of zones from 33 to 16. Consequently, more than 50 employees can be assigned to other tasks.

The method can be easily replicated in other regions and contexts, helping to make the world cleaner while saving money.

Main limitations:
- No information about truck loading: an important parameter to consider zone fusion
- No deep knowledge of field realities

Iterations will be needed