

Selective and periodic inventory routing problem for waste vegetable oil collection

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Abstract We consider a biodiesel production company that collects waste vegetable oil from source points that generate waste in large amounts. The company uses the collected waste as raw material for biodiesel production. The manager of this company needs to decide which of the present source points to include in the collection program, which of them to visit on each day, which periodic routing schedule to repeat over an infinite horizon and how many vehicles to operate such that the total collection, inventory and purchasing costs are minimized while the production requirements and operational constraints are met. For this selective and periodic inventory routing problem, we propose two different formulations, compare them and apply the better performing one on a real-world problem with 36 scenarios. We generate lower bounds using a partial linear relaxation model, and observe that the solutions obtained through our model are within 3.28% of optimality on the average. Several insights regarding the customer selection, routing and purchasing decisions are acquired with sensitivity analysis.

Keywords Reverse logistics · Periodic inventory routing · Mixed integer linear programming · Collection · Waste vegetable oil

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1 Introduction and background

Reverse logistics, recycling and remanufacturing received considerable attention in recent years due to increasing environmental and ecological concerns as well as economical benefits. In addition to saving from direct material costs, companies can also save from disposal and energy costs through reverse logistics and remanufacturing. For example, the cost of virgin oil used in the production of biodiesel constitutes 85% of the total production cost and Encinar et al. [12] state that collecting and using waste vegetable oil costs almost half the price of using virgin vegetable oil in biodiesel production. Recovery of waste vegetable oil plays an essential role in both the environmental and economic sustainability of biodiesel [24]. A total of 108 billion liters of waste vegetable oil is estimated to be generated annually worldwide, but still, out of this quantity only 6 billion liters are collected and used in biodiesel production [1]. In addition to the economical savings, collecting waste vegetable oil has also significant benefits to the environment by decreasing the contamination of rivers, lakes or oceans. One liter of waste oil poured down the drain can contaminate 1 million liters of water and cause serious damage to the environment and the ecological life [1].

Our study is motivated from a biodiesel production facility (*the company*) in Istanbul that collects waste vegetable oils from source points at different locations throughout the city to utilize as input material in biodiesel production. Typically, the source points include businesses that consume cooking oil in large volumes, such as restaurants, hotels and hospitals. The company makes an agreement with each source point and specifies on which days of the week it will collect the accumulated waste oil from that point. The company neither pays nor receives any money from the source points for collecting the waste oils since it is mandatory for the source points to give their waste oils to recovery facilities by law. Waste vegetable oils accumulate at different rates at the source points and uncollected amounts at any day are carried on to the next day. Thus, the company may prefer to wait for several days in order to allow a high enough amount to accumulate at a location before visiting it.

The company follows a predetermined production plan that dictates the daily input requirements for vegetable oil. It can satisfy the vegetable oil needed for biodiesel production either by the waste vegetable oil it collects or by purchasing virgin oil, but the latter is considered to be more costly in general. The manager needs to decide on how much waste vegetable oil to collect from the source points and how much to purchase on each day, depending on the available inventory at hand, in order to satisfy the input requirements for production. The manager also needs to decide on vehicle routes in order to perform the collection at minimum cost. Moreover, the amount of waste vegetable oil accumulated at the source points might be more than the amount needed for production. In this case visiting all the source points will not be necessary. Hence, the manager picks the source points to make a collection agreement with. The company can also keep an inventory of waste vegetable oil at its production facility. In this study, we determine which of the potential source points to include in the collection program, which of them to visit on each day, which periodic routing schedule to repeat over an infinite horizon and how many vehicles to operate such that the total collection, inventory and purchasing costs are minimized while the production requirements and operational constraints are met.