

Supplementary Material

1 Supplementary Tables

The Tables related to the issue were collected separately and are used to support and analyze the data presented in the study

TABLE 1 Shortest route for each vehicle using CQL

No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 1 \rightarrow 2 \rightarrow D \rightarrow C$	2.376	$C \rightarrow 1 \rightarrow 2 \rightarrow D \rightarrow C$	2.46
A_3	$C \rightarrow 3 \rightarrow 7 \rightarrow 8 \rightarrow D \rightarrow C$	1.744	$C \rightarrow 3 \rightarrow 7 \rightarrow 8 \rightarrow D \rightarrow C$	1.717
A_4	$C \rightarrow 4 \rightarrow 9 \rightarrow 10 \rightarrow D \rightarrow C$	1.646	$C \rightarrow 4 \rightarrow 9 \rightarrow 10 \rightarrow D \rightarrow C$	1.766
A_5	$C \rightarrow 5 \rightarrow 6 \rightarrow D \rightarrow C$	0.875	$C \rightarrow 5 \rightarrow 6 \rightarrow D \rightarrow C$	0.902
A_6	$C \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow D \rightarrow C$	1.496	$C \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow D \rightarrow C$	1.358
A_7	$C \rightarrow 14 \rightarrow D \rightarrow C$	0.582	$C \rightarrow 14 \rightarrow D \rightarrow C$	0.657

TABLE 2 Shortest route for each vehicle using DQN

No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 1 \rightarrow 2 \rightarrow 9 \rightarrow 6 \rightarrow D \rightarrow C$	2.981	$C \rightarrow 1 \rightarrow 2 \rightarrow 9 \rightarrow 6 \rightarrow D \rightarrow C$	2.997
A_3	$C \rightarrow 4 \rightarrow 8 \rightarrow D \rightarrow C$	1.837	$C \rightarrow 4 \rightarrow 8 \rightarrow D \rightarrow C$	1.885
A_4	$C \rightarrow 10 \rightarrow 13 \rightarrow 11 \rightarrow 12 \rightarrow D \rightarrow C$	1.705	$C \rightarrow 10 \rightarrow 13 \rightarrow 11 \rightarrow 12 \rightarrow D \rightarrow C$	1.672
A_5	$C \rightarrow 5 \rightarrow 3 \rightarrow 7 \rightarrow 14 \rightarrow D \rightarrow C$	2.169	$C \rightarrow 5 \rightarrow 3 \rightarrow 7 \rightarrow 14 \rightarrow D \rightarrow C$	2.306

TABLE 3 Shortest route for each vehicle using A*

No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 1 \rightarrow 2 \rightarrow 6 \rightarrow 3 \rightarrow D \rightarrow C$	2.972	$C \rightarrow 1 \rightarrow 2 \rightarrow 6 \rightarrow D \rightarrow C$	2.651
A_3	$C \rightarrow 4 \rightarrow 9 \rightarrow 10 \rightarrow 5 \rightarrow 7 \rightarrow D \rightarrow C$	2.908	$C \rightarrow 4 \rightarrow 9 \rightarrow 10 \rightarrow 5 \rightarrow 7 \rightarrow D \rightarrow C$	2.988
A_4	$C \rightarrow 13 \rightarrow 11 \rightarrow 12 \rightarrow 8 \rightarrow 14 \rightarrow D \rightarrow C$	2.812	$C \rightarrow 13 \rightarrow 11 \rightarrow 12 \rightarrow 8 \rightarrow 14 \rightarrow D \rightarrow C$	2.794
A_5	-----	0	$C \rightarrow 3 \rightarrow D \rightarrow C$	0.427

TABLE 4 Shortest route for each vehicle using A* with DQN

No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 1 \rightarrow 9 \rightarrow 3 \rightarrow 7 \rightarrow 8 \rightarrow D \rightarrow C$	2.982	$C \rightarrow 1 \rightarrow 9 \rightarrow 7 \rightarrow 8 \rightarrow D \rightarrow C$	2.241
A_3	$C \rightarrow 4 \rightarrow 5 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow D \rightarrow C$	2.948	$C \rightarrow 4 \rightarrow 5 \rightarrow 10 \rightarrow 11 \rightarrow D \rightarrow C$	2.809
A_4	$C \rightarrow 2 \rightarrow 6 \rightarrow 14 \rightarrow 13 \rightarrow D \rightarrow C$	2.762	$C \rightarrow 2 \rightarrow 6 \rightarrow 14 \rightarrow 13 \rightarrow D \rightarrow C$	2.558
A_5	-----	0	$C \rightarrow 12 \rightarrow 8 \rightarrow D \rightarrow C$	1.252

TABLE 5 Shortest route for each vehicle using CDQN

No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 2 \rightarrow 5 \rightarrow 11 \rightarrow 12 \rightarrow D \rightarrow C$	2.922	$C \rightarrow 2 \rightarrow 5 \rightarrow 11 \rightarrow D \rightarrow C$	2.641
A_3	$C \rightarrow 10 \rightarrow 3 \rightarrow 6 \rightarrow 7 \rightarrow 8 \rightarrow 13 \rightarrow D \rightarrow C$	2.874	$C \rightarrow 10 \rightarrow 3 \rightarrow 6 \rightarrow 7 \rightarrow 8 \rightarrow 13 \rightarrow D \rightarrow C$	2.68
A_4	$C \rightarrow 4 \rightarrow 1 \rightarrow 9 \rightarrow 14 \rightarrow D \rightarrow C$	2.896	$C \rightarrow 4 \rightarrow 1 \rightarrow 9 \rightarrow D \rightarrow C$	2.409
A_5	-----	0	$C \rightarrow 12 \rightarrow 14 \rightarrow D \rightarrow C$	1.13

TABLE 6 Shortest route for each vehicle using FKPDQN

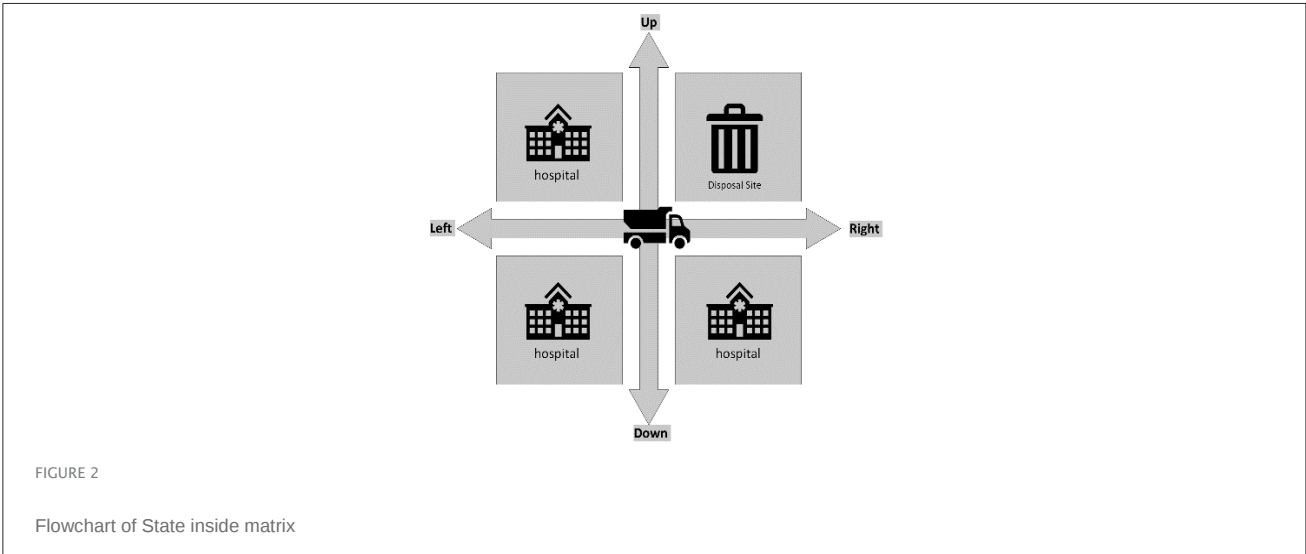
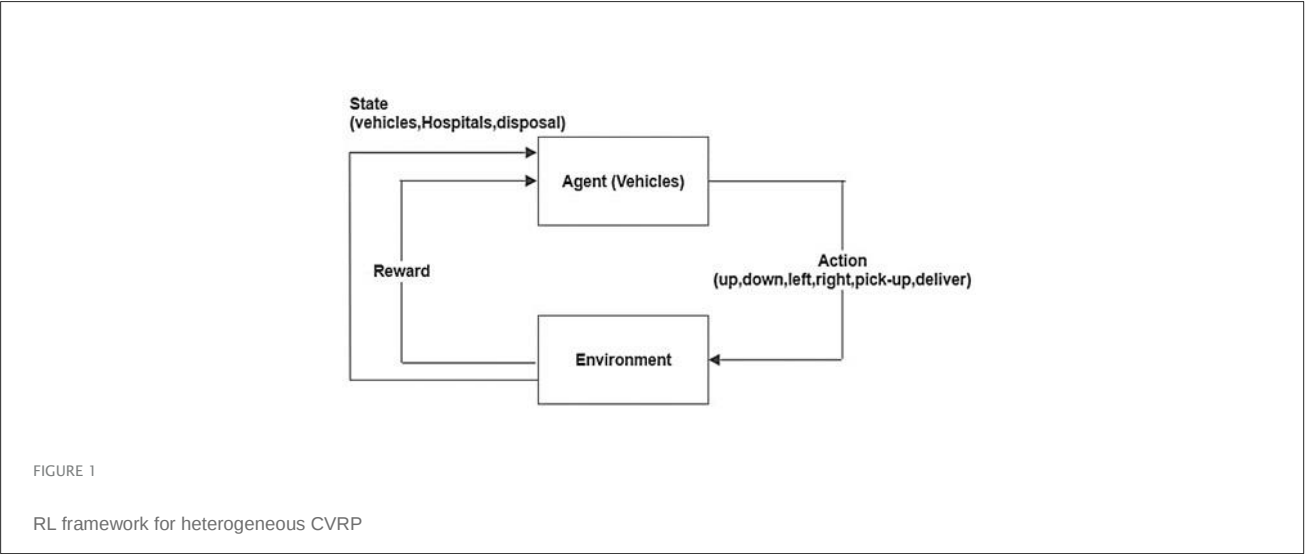
No.	Vehicle Route in the week	Cap	Vehicle Route in the week	Cap
A_1	$C \rightarrow 15 \rightarrow D \rightarrow C$	3	$C \rightarrow 15 \rightarrow D \rightarrow C$	3
A_2	$C \rightarrow 10 \rightarrow 7 \rightarrow 6 \rightarrow 3 \rightarrow 13 \rightarrow 11 \rightarrow 9 \rightarrow 4 \rightarrow D \rightarrow C$	3	$C \rightarrow 10 \rightarrow 7 \rightarrow 6 \rightarrow 3 \rightarrow 13 \rightarrow 11 \rightarrow 9 \rightarrow 4 \rightarrow D \rightarrow C$	3
A_3	$C \rightarrow 4 \rightarrow 5 \rightarrow 8 \rightarrow 2 \rightarrow D \rightarrow C$	3	$C \rightarrow 4 \rightarrow 5 \rightarrow 8 \rightarrow 2 \rightarrow D \rightarrow C$	3
A_4	$C \rightarrow 2 \rightarrow 12 \rightarrow 1 \rightarrow 14 \rightarrow D \rightarrow C$	2.692	$C \rightarrow 2 \rightarrow 12 \rightarrow 1 \rightarrow 14 \rightarrow D \rightarrow C$	2.860

TABLE 7 Percentage Comparison Based on Reference (Optimal) Values

Metric	CQL	A*	DQN	A* with DQN	CDQN	Fractional Knapsack with DQN (FKPDQN)
Number of Vehicles	7 (42.86% increase)	5 (20% increase)	5 (20% increase)	5 (20% increase)	5 (20% increase)	4 (0% loss)
Vehicle Capacity Utilization	33% (-67%)	66% (-34%)	66% (-34%)	50% (-50%)	60% (-40%)	100% (optimal)
Distance	622.43 km (+17.5%)	529.6 km (reference)	609.2 km (+15%)	588.3 km (+11%)	599.43 km (+13%)	580.2 km (+9%)
Time	1006 min (+19%)	841 min (reference)	912 min (+8.5%)	949 min (+12.8%)	940 min (+11.8%)	913 min (+8.5%)
Fuel Cost	\$20.39 per liter (+17%)	\$17.35 per liter (reference)	\$19.96 per liter (+15%)	\$19.27 per liter (+11%)	\$19.64 per liter (+13%)	\$19.01 per liter (+9%)
Battery Cost	\$2.61 per unit (+15%)	\$2.22 per unit (reference)	\$2.55 per unit (+15%)	\$2.47 per unit (+11%)	\$2.51 per unit (+13%)	\$2.43 per unit (+9%)

2 **Supplementary Figures**

The figures related to the issue were collected separately and are used to support and analyze the data presented in the study.



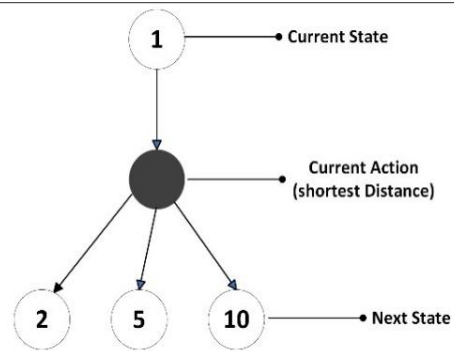


FIGURE 3

Relationship State and Actions

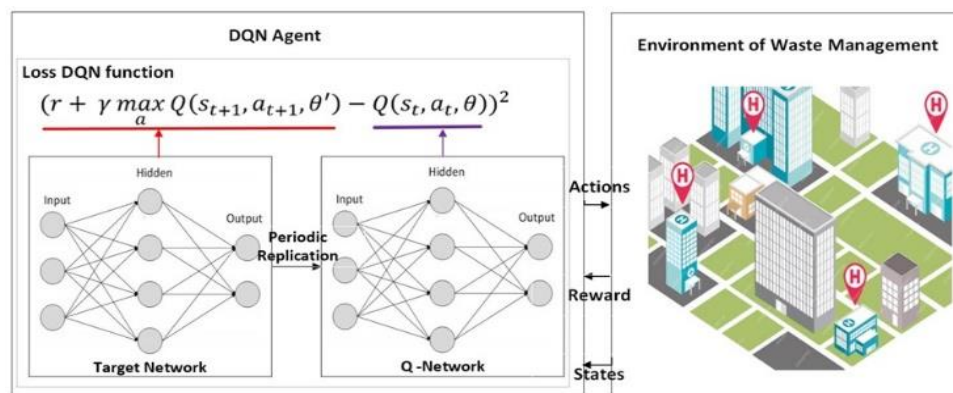


FIGURE 4

A diagram of deep Q network algorithm

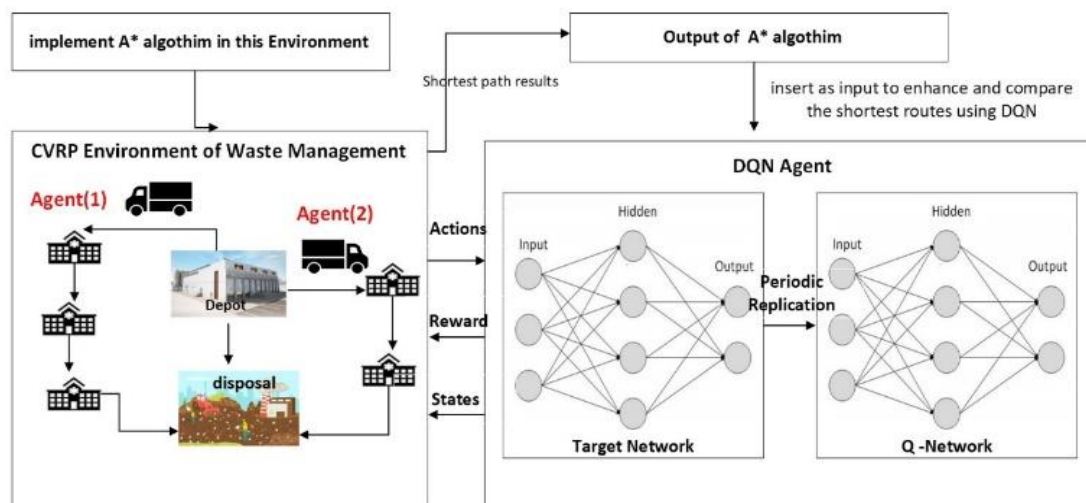


FIGURE 5

A Diagram of hybridization between A* and DQN

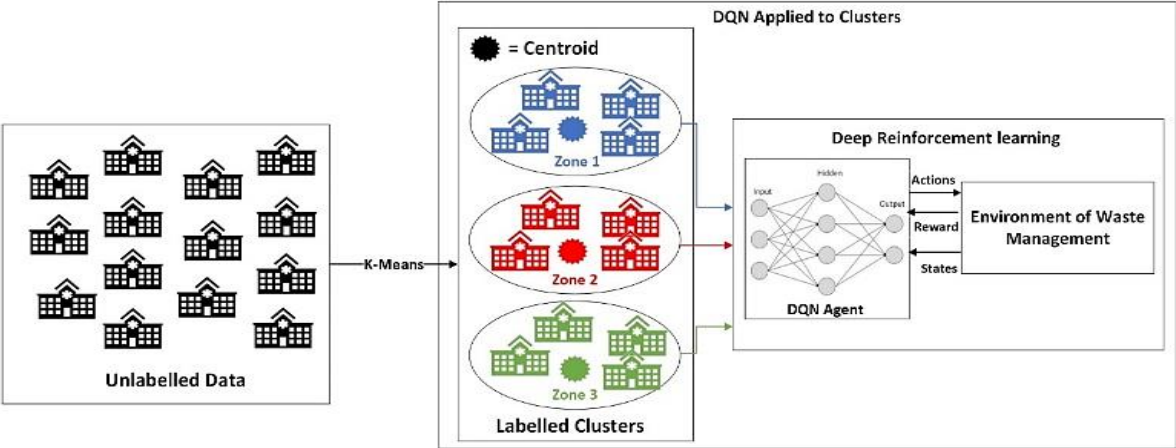


FIGURE 6
Diagram of K-means and DQN Hybridization

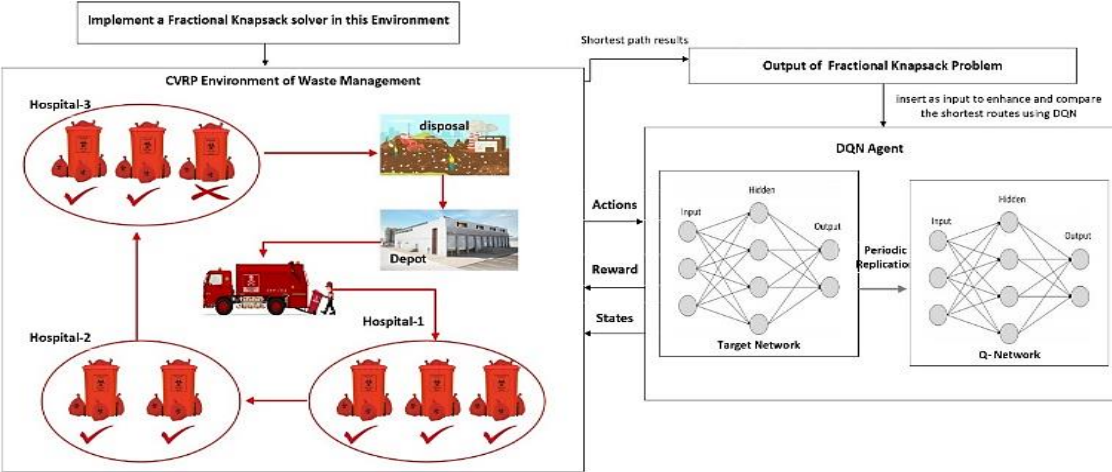


FIGURE 7
Diagram of FKP and DQN Hybridization

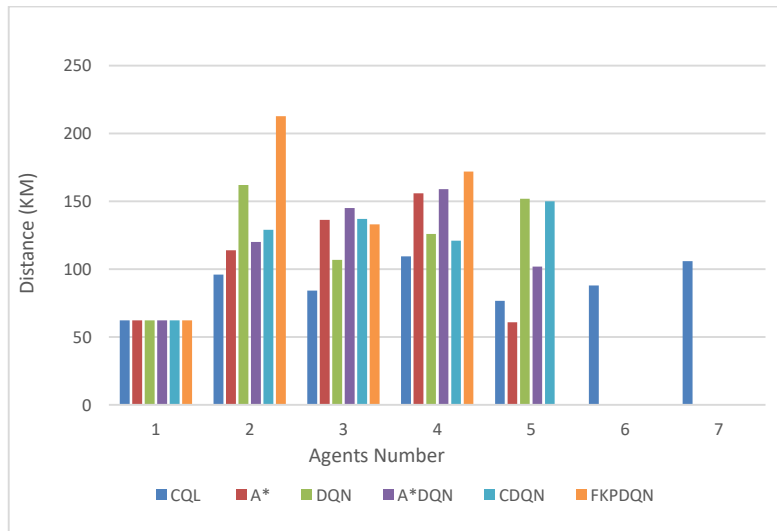
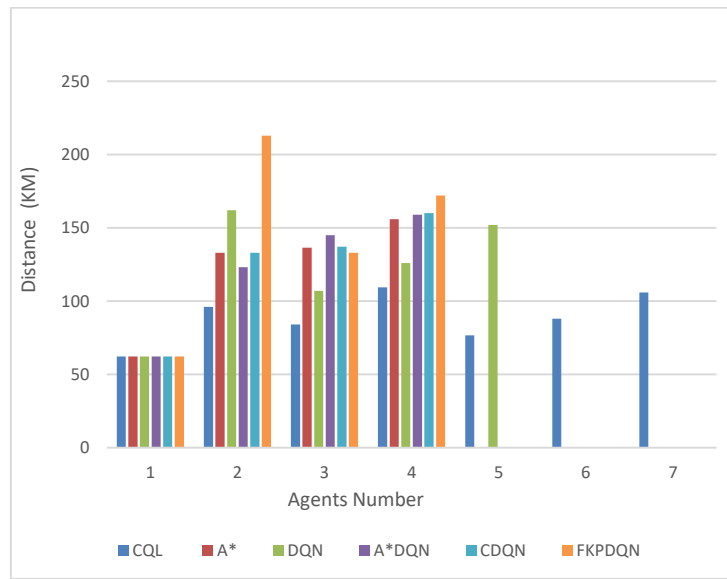


FIGURE 9

Estimated distance per agent during 2nd visit

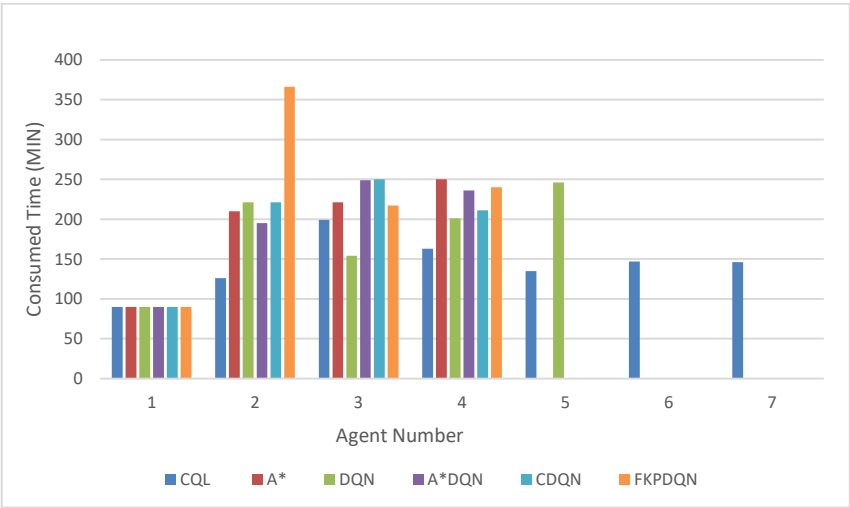


FIGURE 10
Time spent per agent during the 1st visit

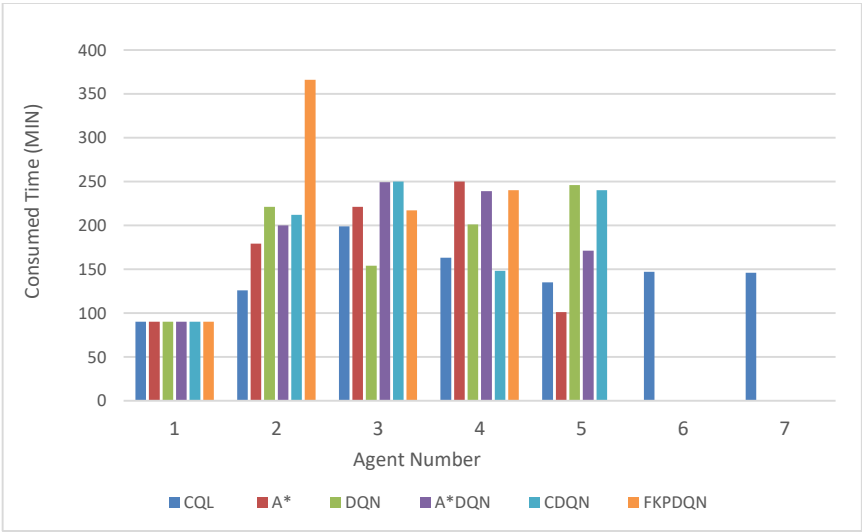


FIGURE 11
Time spent per agent during the 2nd visit

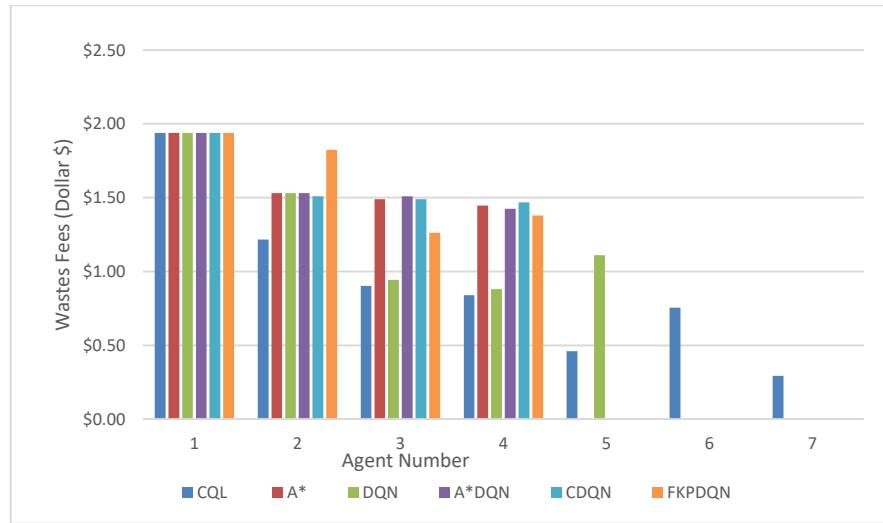


FIGURE 12

Fees of hospitals wastes during 1st visit

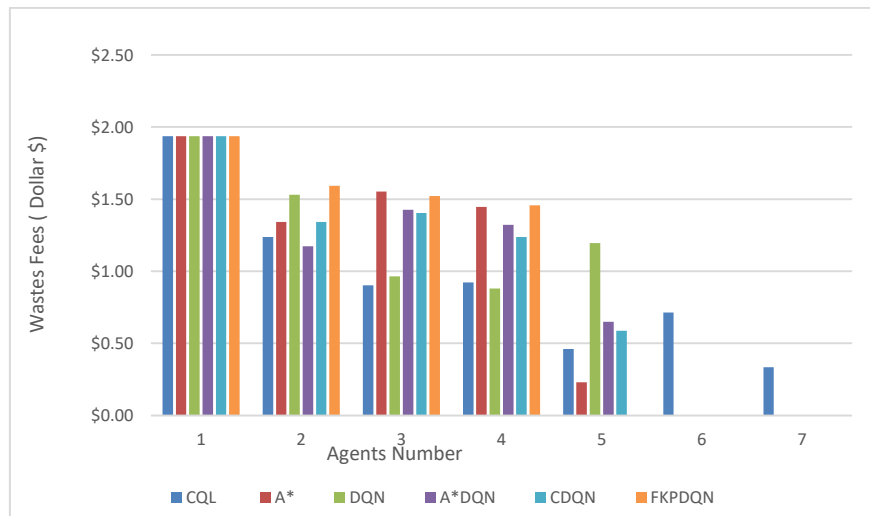


FIGURE 13

Fees of hospitals wastes during 2nd visit

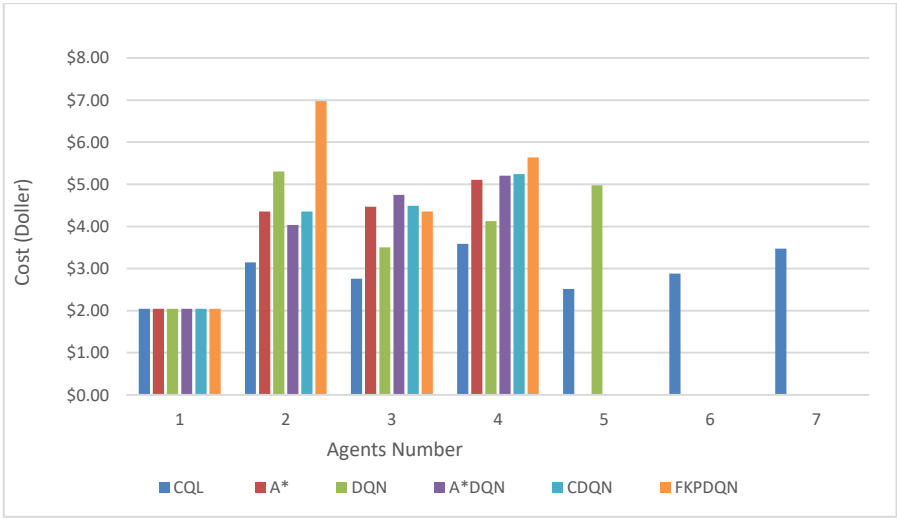


FIGURE 14

Transportation cost by using fuel during 1st visit

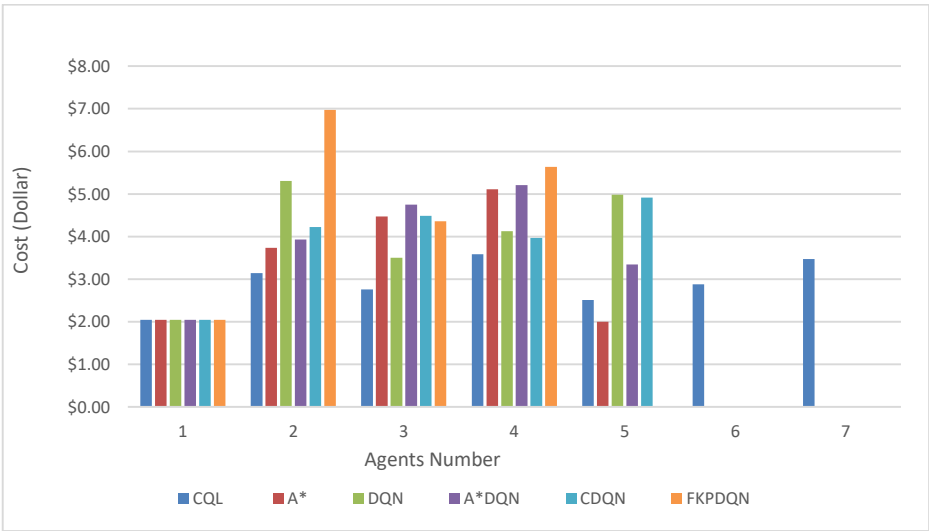


FIGURE 15

Transportation cost by using fuel during 2nd visit

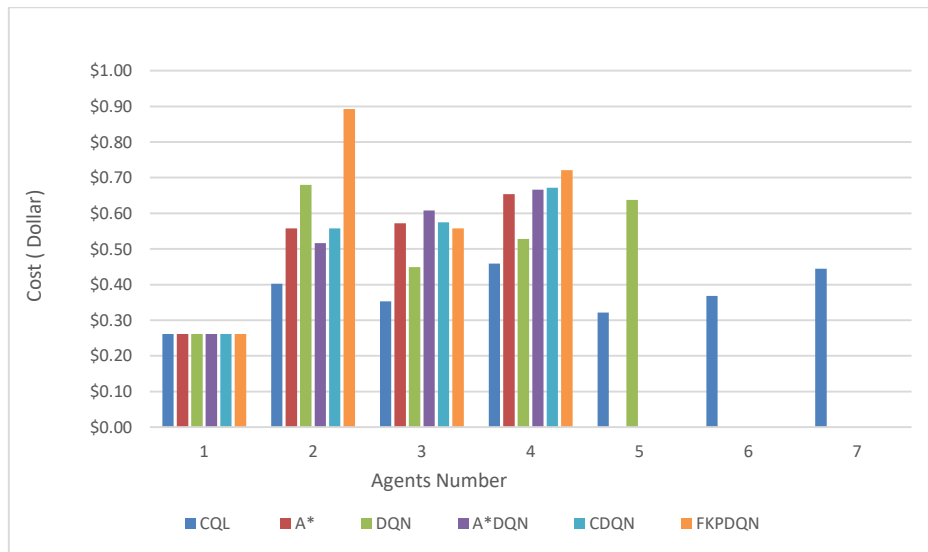


FIGURE 16

Transportation cost by Electric agents during 1st visit

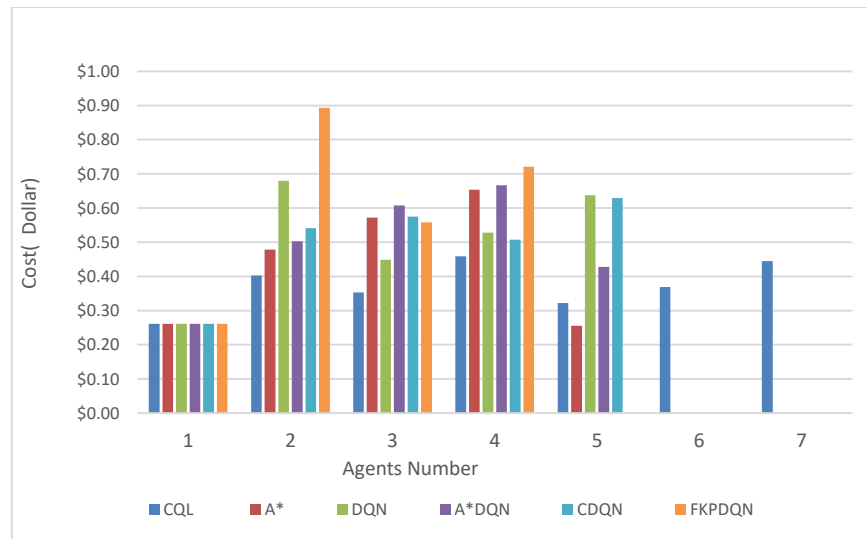


FIGURE 17

Transportation cost by Electric agents during 2nd visit