Cars and Harmful Ozone

New Mexico

Supercomputing Challenge

Final Report

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Executive Summary:

My project is on cars and their effect on harmful ozone. Ozone in the tropospheric layer of the atmosphere is very harmful to humans causing many respiratory problems. It has four main components: nitrogen oxides, carbon monoxides, other volatile organic compounds, and sunlight or heat. Albuquerque, right now, is good and sometimes moderate in tropospheric ozone levels, but my concern is for the future Albuquerque, where ozone levels are so high that it is affecting human health. How can we reduce this or prevent this from happening?

I used StarLogo TNG to model my program. My model has a moving sun that emits sunlight and heat as it moves from one edge to the other, and VOCs being produced by scattered Buildings. There are two sets of cars in my model, one set being the cars that we use today, and the other, Green Cars that produce only half of the greenhouse gases that the other cars produce. The cars produce nitrogen oxides and carbon monoxides. The carbon monoxides, nitrogen oxides, VOCs, and sunlight/heat molecules move upward and settle at a certain altitude, then colliding with each other to form Ozone molecules. I have graphs and monitors keeping track of the ozone, and its four main components. Once the sun reaches the opposite end from where it started, it disappears, reducing the number of both sets of cars to about half of the original number. Also, there are certain halogen species in the air that destroy the ozone when they collide with it.

As for my procedure, I set the number of Cars to 30 and ran the model for 74 seconds. Then, I saved the data from the graphs and ran four more tests with it, saving the data from each test. After that, I replaced 5 Cars with 5 Green Cars and ran the model five times, saving the data for each. After every five tests, I replaced a greater number of Cars agents with Green Cars agents, and recorded the data collected.

My results were these: When I ran the model with 30 Car agents, the Ozone agents present at the end of the model, were (in order of test #) 327, 308, 295, 294, and 307, with an average of 306. For 20 Car agents I got 327, 332, 277, 267, and 285, with an average of 298. When I had only 10 Cars, my results showed that there were 276, 288, 305, 275, and 282 Ozone agents at the end of the model, with an average of 285.

As the results show, when I replaced the Cars agents with Green Cars, there were fewer Ozone Agents in the model. My model and results suggest that if we carpool, use green cars, or use public transportation more often, then future Albuquerque won’t have to worry about the dangerous conditions that tropospheric ozone causes.

Introduction:

Ozone is found in two different layers of the atmosphere: the stratosphere and the troposphere. “Good” ozone is found in the lower part of the stratosphere and ranges from 13 to 40 kilometers above Earth. Ultraviolet rays can cause skin cancer, malignant melanoma, photocarcinogenesis, and many more health problems. Stratospheric ozone absorbs 97-99% of the Sun’s ultraviolet rays, therefore protecting us from their harmful effects.

The focus of my project is on tropospheric ozone. The troposphere is the lowest portion of the Earth’s atmosphere, and the ozone in this layer is commonly referred to as “bad” ozone. This type of ozone is exceptionally harmful because it deeply affects your respiratory system. Some of the conditions it can cause are shortness of breath, aggravation of asthma, pneumonia, bronchitis, acute inflammation of the lining of lung cells, an increase in allergic symptoms, and etc. Some studies also show that it may be able to decrease the immune system’s capability of protecting the human body from bacterial infections.

Tropospheric ozone has four main components; nitrogen oxides, carbon monoxides, other volatile organic compounds, and sunlight or heat. Nitrogen oxides and carbon monoxides are both mainly produced by car, factory, and power plant emissions. VOCs (volatile organic compounds) are created by a large number of everyday items, such as items having to do with paint, copiers, printers, permanent markers, pesticides, cleaning supplies, and etc.

In Albuquerque, it is recorded, according to the Air Quality Index of the AirNow Website, that in the past few months, tropospheric ozone layers ranked from 0-50 most of the time, which is good, and at the rarest occasion, from 51-100, which is moderate. But my research showed that bigger, more industrialized cities, such as New York, are often ranked 101-150, which is unhealthy for sensitive groups, and sometimes 151-200, which is unhealthy, meaning that everyone could begin to experience harmful effects.

Albuquerque is still a growing city and its tropospheric ozone levels are mostly good but sometimes moderate. My concern, although, is for the future Albuquerque, where the city we know has far changed, with large numbers of greenhouse gas-producing cars running around, and plentiful factories and power plants. The tropospheric ozone levels will be high here, so the people of Albuquerque will suffer from the respiratory problems caused by the harmful human health effects by tropospheric ozone. How can we control this increase in tropospheric ozone? What can we do to prevent it?

My purpose in choosing this investigation was to create a model that proves, the emissions caused by the large number of cars are the cause of large amounts of tropospheric ozone. This is what I wanted to find out: if we replace a large number of the greenhouse gas emitting cars with more green cars that produce less carbon monoxides and nitrogen oxides, would there be a significant decrease in the tropospheric ozone level?

Description:

My model is programmed on StarLogo TNG. I have many sets of agents in this model, and some interact with each other to form tropospheric ozone molecules. The agents in my model are the Sun, Nitrogen Oxides, VOCs, Cars, Factories, Sunlight & Heat, Factory Men, Ozone, Ozone Men, Carbon Monoxides, Buildings, Ozone Men 2, Wall, Halogen Species, and Green Cars.

The Sun agents in this model represent the sun in the real world. They move from one end of the model to another, starting at x axis –50 and y axis 0, and ending at x axis 50 and y axis 0. It moves at altitude 50, and is set to a size of 8, although this size is not directly proportional to the real sun, as it is much larger, and it is a bright yellow sphere. The Sun moves by moving up 0.01 steps and moving forward 0.5 steps. It moves up 0.01 steps because to create Sunlight & Heat agents, it has to test its altitude, and if the altitude is not equal to 50 (because it moved up 0.01 steps), then it will hatch a Sunlight & Heat agent, and move down 0.01 steps. This procedure is repeated over and over again until the Sun reaches the other end of the model. I have 5 sun agents in this model because I found that one Sun agent did not hatch enough Sunlight & Heat agents, and 5 hatched a sufficient amount of such agents. The Sun also disappears after it reaches the other end of the model, colliding with the Wall, representing the end of day and the beginning of night. The Wall is placed at altitude 50, and x axis 50 and y axis 0, which is where the Sun has to move to.

The Nitrogen Oxides are one of the components of Ozone, and is created by Cars and Green Cars, as they move around. They are magenta and are set to size .5 in my model. Once they are produced, they test their altitude, and if it is not equal to 25, they move up 1 step. After they reach altitude 25, they move 2 steps forward in random directions.

Scattered Buildings produce the VOCs in my model. They are blue and are set to size .5, just like the Nitrogen Oxides and the other two components. Once they are produced, they too, test their altitude, and if it is not equal to 25, they set their heading in a random direction and move forward 1 and up 1. When they reach altitude 25, they move 2 steps forward in random direction. The reason why they go forward a step and then up 1 when they are produced, is because the buildings remain stationary and the VOC molecules need to be scattered around.

I have two different sets of Cars in my model. The first is merely named Cars and represents the cars that we drive today that emit the high levels of carbon monoxides and nitrogen oxides. They move forward 10 steps, which represents a mile, and set their heading in a random direction. Then, if the heading is less than 90, they hatch Nitrogen Oxides, and if the heading is greater than 90 and less than 270, they hatch Carbon Monoxides. Because way more carbon dioxides are emitted by cars than nitrogen oxides in real life, it only seemed appropriate to give a larger chance to Carbon Dioxides to be created. Also, once the Sun reaches the Wall, and disappears, a shared boolean block allows the Cars to check whether the Sun is up, and if it isn't then around half of them die. The second of my set of cars is called Green Cars. These are the more "green" cars that I plan on replacing the original Cars with to check the differences in ozone level. They are green and do everything exactly the same as Cars, but they only hatch Nitrogen Oxides if their heading is less than 45 and Carbon Monoxides if their heading is greater than 90 and less than 180. This cuts the amount of Carbon Monoxides and Nitrogen Oxides bring produced in half.

The Factory agent in this model acts with the Factory Men agents to create Nitrogen Oxides and Carbon Monoxides. The Factory is originally black and it is set at size 3. The Factory Men follow one basic rule: they set their heading in a random direction and take ten steps forward. As the 10 Factory Men at size .1 move around, if they collide with the Factory, they set its color to green and keep on following their basic rule. The Factory is constantly checking to see if their color is green, because when it is, they hatch Nitrogen Oxides and Carbon Monoxides agents, and then set their color to black.

The Sunlight & Heat agents of this model are created by the Sun as it moves from one end of the model to the other end. They are yellow, and like the other components of ozone, they are set at size .5. The Sunlight & Heat agents, once they are created, check to see if they are at an altitude that is greater or equal to 26 and if they are, they move a number of steps in a random choice of 10 in the heading of a random direction, and then down 1 until they reach the altitude 25. When they get there, they move forward 2 steps in random directions.

The Carbon Monoxides are turquoise and are set at size .5. Once they are produced by Cars, Green Cars, or Factory, they check to see whether they're altitude is equal to 25, and if it isn't, they set their heading to random 360 and move forward 1 and up. Once they reach altitude 25, they move 2 steps forward in random directions.

There are 10, hidden buildings in my model. They are hidden, because VOCs are created by so many different household products, it is hard to model them all. They set their heading in a random direction and if their heading is less than 90, they hatch VOCs agents that are made visible, blue, and at size .5.

In this model, Ozone is produced in a three-step collision sequence, which occurs at altitude 25, because that is where all four components end up: the Sunlight & Heat, VOCs, Nitrogen Oxides, and Carbon Monoxides. The first step is when the Nitrogen Oxides and Carbon Monoxides agents collide. The Nitrogen Oxide agent dies, and the Carbon Monoxide agent changes its breed to a different agent called Ozone Man. Ozone Man is invisible, and moves forward in random directions at altitude 25. The second step is when the VOCs and Ozone Man collide, the Ozone Man dies, and the VOCs agent changes its breed to Ozone Man 2. This second type of Ozone Man also follows the exact same rules as Ozone Man. Ozone Man 2 collides with Sunlight & Heat, which is the third step of the creation of an Ozone agent. Ozone Man 2 dies, and Sunlight & Heat changes its breed to Ozone and changes its color to orange. Once the Ozone is created, it checks it altitude to see whether its less than or equal to 35, and if it is, it moves up one step, until it reaches altitude 35. At altitude 35, it moves forward 2 steps in random directions.

There are also 50 agents called Halogen Species at altitude 35 that move forward 2 steps in random directions. They represent the halogen species in the troposphere that destroy ozone. The Ozone collides with these agents, and they set their heading in a random direction, and if they're heading is less than or equal to 90, they die.

In my setup area in StarLogo TNG, I've asked it to reset the clock, and clear all before every test. I also have a chart that counts the number of the four components that are present over time, and a chart that counts the Ozone. I also have individual monitors counting the Ozone, Cars, Green Cars, Nitrogen Oxides, Carbon Monoxides, VOCs, and

Sunlight & Heat. I wanted to count the exact number of ozone and the four components during and at the end of each test. I counted the Cars and Green Cars to make sure that when the Sun disappears, half the number of both breeds dies. The setup area also contains the shared boolean “Sun Up”. Everytime I start the model, it sets this boolean to true, and when the Sun collides with the Wall, the Sun sets this boolean to false. Both sets of cars check to see whether the boolean is false, and if it is, around half of them disappear.

In the Runtime area of the model, I’ve set the model to run for 74 seconds, which is twice the amount of time it takes for the Sun to get from one end to the other end of the model. This is also the place where I set each of agents to follow my procedures, by linking them up with the correct procedure boxes. There is also a “run once” block in the Runtime area, which achieves getting rid of half the cars in the model when the Sun hits the Wall.

To run the model, I click the Setup button, which creates everything that I have modeled into Spaceland, where the model actually runs, and then the Run button starts the model. When the Sun hits the Wall and disappears, I hit the “run once” button, which reduces the number of cars to about a half of the original number, and then wait till the model ends. After the model ends, I save the data and the image and then conduct a couple more tests.

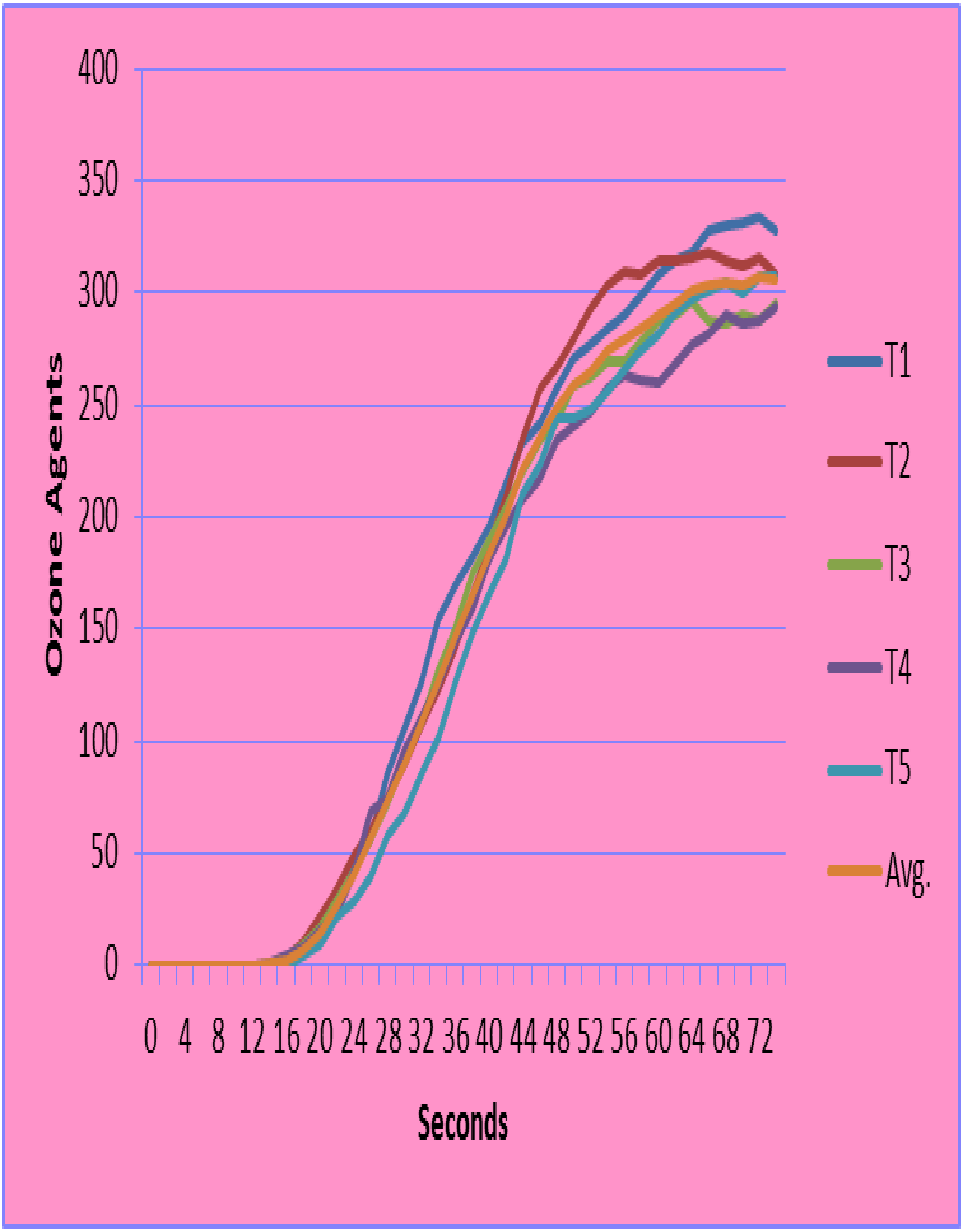
This is how I ran my tests. At first, I set the number of Cars to 30 and then ran the model. After 74 seconds the model stopped, and I saved the Components Chart and the Ozone Chart’s data onto Excel. I ran four more tests with 30 Cars and saved the data collected. Then, I did the same procedure as above with 25 Cars and 5 Green Cars, and conducted the same procedure as above. Then I kept on replacing the number of Cars with Green Cars with a total of 30 cars, and running five tests for each set of Cars Agents (20, 15, 10, 5, 0). Afterwards, I put together the data collected for the five tests of each set of cars and made a line graph out of the data. For example, I took the data collected from the five tests with 30 Cars Agents and put them in one Excel Sheet. Then, I added one line graph that graphed the Ozone molecule production for each test over 74 seconds. I also added an average column to my data, and added the Average Line on my chart as well. Like I've mentioned above, I did this with all the set of cars. After I graphed each set of cars, I graphed the averages of all the sets of cars together. All in all, I have 8 graphs to show.

Results:

My results were these: When I ran the model with 30 Car agents, the Ozone agents present at the end of the model, were (in order of test #) 327, 308, 295, 294, and 307, with an average of 306. When 5 Green Cars agents replaced 5 Cars agents, my results were 302, 290, 291, 311, and 314, with an average of 302. For 20 Car agents I got 327, 332, 277, 267, and 285, with an average of 298. When 15 Green Cars agents stood in the place of 15 Cars agents, I got 290, 270, 315, 305, and 270, with an average of 290. When I had only 10 Cars, my results showed that there were 276, 288, 305, 275, and 282 Ozone agents at the end of the model, with an average of 285. 5 Car agents gave me 282, 312, 254, 275, and 249 Ozone molecules, with an average of 274 Ozone molecules. Finally, when I replaced all the Cars agents with Green Cars Agents, I got 281, 236, 286, 231, and 299 Ozone agents from my test, and calculated an average of 267 Ozone agents present at the end of the model.

Results for 30 Cars:

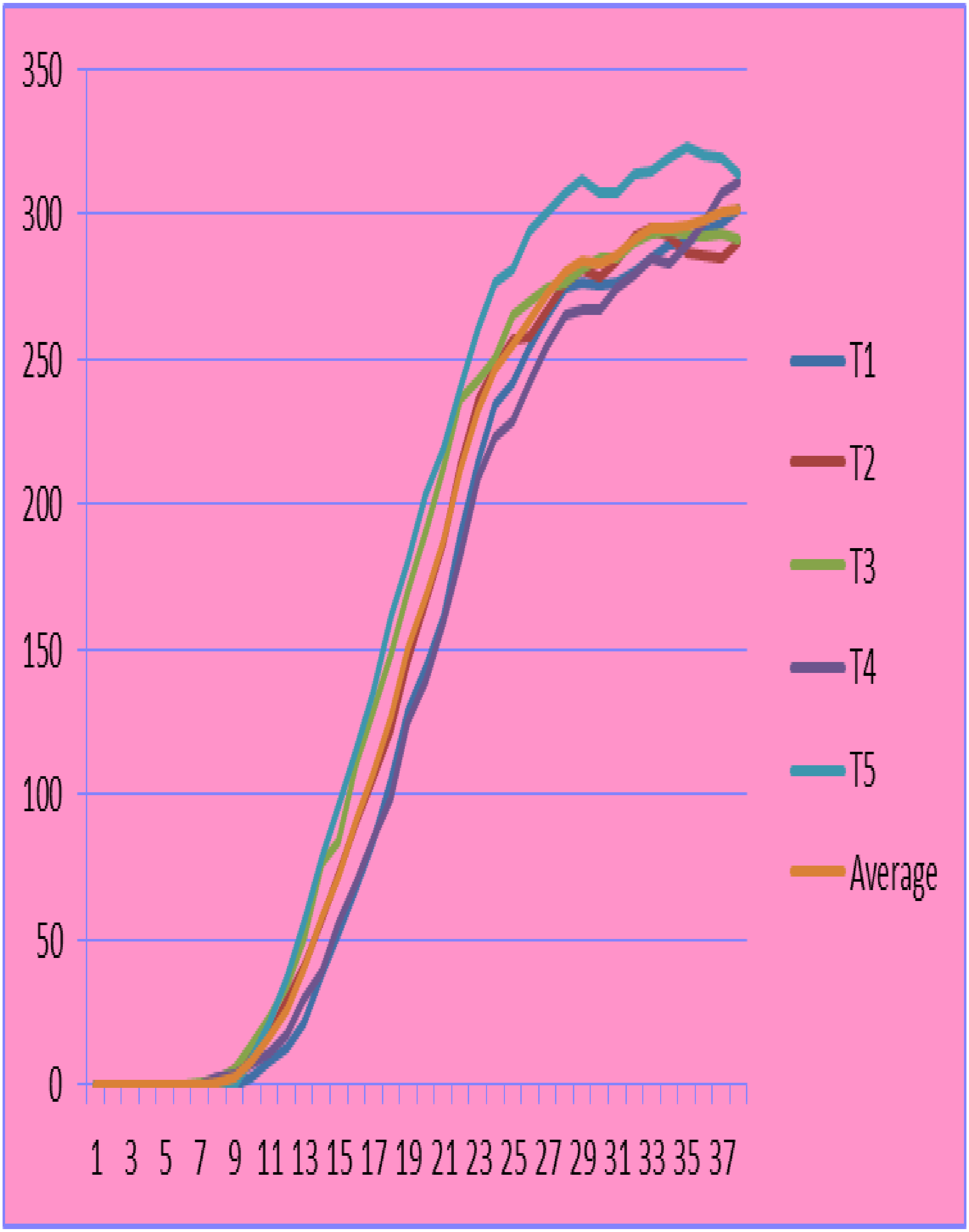
Secs	T1	T2	T3	T4	T5	Avg.
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	0	0	0
14	0	0	0	1	0	0.2
16	0	3	3	4	0	2
18	6	10	9	8	4	7.4
20	11	21	16	15	9	14
22	23	33	29	23	21	26
24	44	49	42	42	28	41
26	56	60	56	68	40	56
28	85	75	72	75	58	73
30	105	89	92	95	67	90
32	127	107	109	111	86	108
34	155	123	131	125	101	127
36	169	141	150	144	125	146
38	182	165	175	159	148	166
40	196	187	189	181	165	184
42	215	209	204	196	181	201
44	233	234	220	208	210	221
46	242	257	234	218	224	235
48	257	267	243	234	244	249
50	271	279	259	241	244	259
52	277	292	262	246	248	265
54	284	303	269	257	256	274
56	290	309	269	263	266	279
58	299	308	278	261	274	284
60	308	314	288	260	282	290
62	314	314	290	268	291	295
64	318	315	296	277	297	301
66	328	318	287	282	301	303
68	330	314	286	290	305	305
70	331	312	290	286	300	304
72	334	316	288	288	307	307
74	327	308	295	294	307	306



400
350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
T1
T2
T3
T4
T5
Avg.

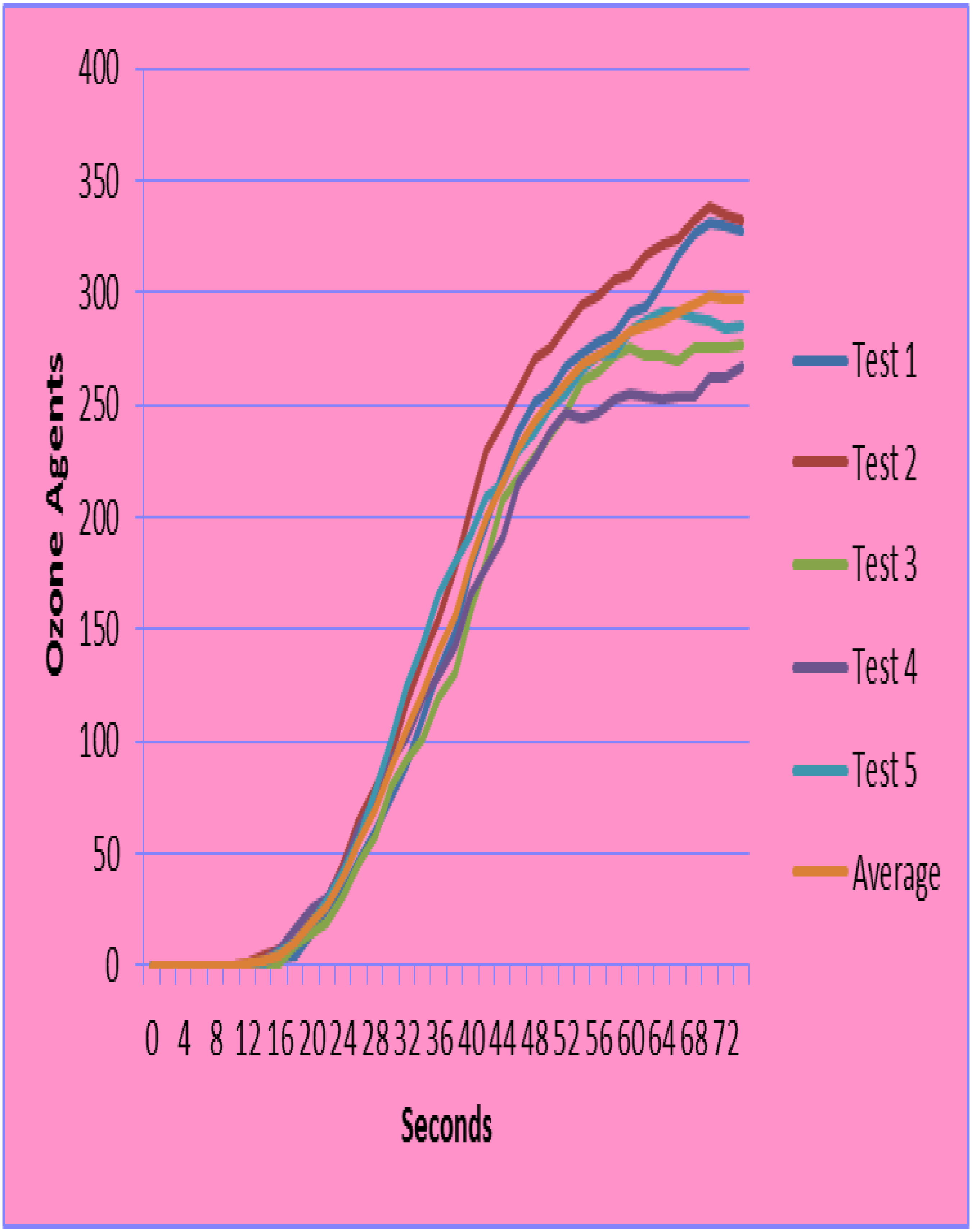
Results for 25 Cars:

Secs	T1	T2	T3	T4	T5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	1	0	0	0.2
14	0	1	2	3	0	1.2
16	0	5	5	4	0	2.8
18	3	10	14	7	9	8.6
20	8	18	23	11	21	16.2
22	13	30	34	18	37	26.4
24	21	41	50	30	56	39.6
26	38	57	76	39	78	57.6
28	52	73	84	56	96	72.2
30	68	90	111	70	116	91
32	84	105	129	85	135	107.6
34	105	122	148	99	161	127
36	129	146	170	125	180	150
38	144	166	190	139	203	168.4
40	161	187	213	160	219	188
42	189	214	236	182	240	212.2
44	215	236	243	209	260	232.6
46	234	247	250	223	276	246
48	242	257	265	229	281	254.8
50	254	258	270	242	294	263.6
52	265	267	274	255	301	272.4
54	274	276	276	265	307	279.6
56	276	281	281	267	312	283.4
58	275	278	285	267	307	282.4
60	276	284	285	274	307	285.2
62	280	292	290	279	314	291
64	285	295	293	285	315	294.6
66	289	292	294	283	319	295.4
68	290	287	293	289	323	296.4
70	294	286	292	297	320	297.8
72	297	285	293	307	319	300.2
74	302	290	291	311	314	301.6


350
300
250
200
150
100
50
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
T1
T2
T3
T4
T5
Average

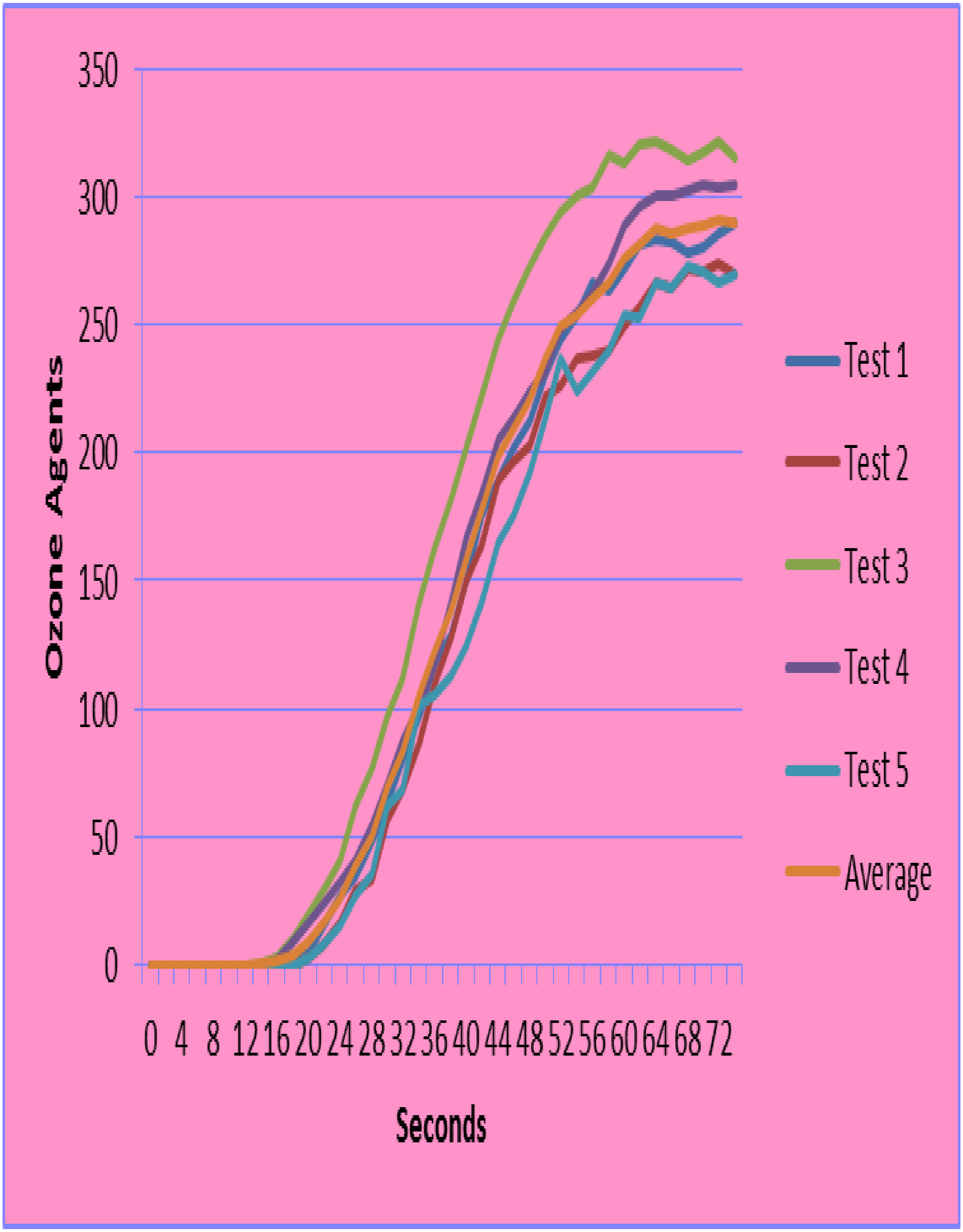
Results for 20 Cars:

Secs	Test 1	Test 2	Test 3	Test 4	Test 5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	1	0	0	0	0.2
14	2	4	0	2	1	1.8
16	3	7	1	7	6	4.8
18	5	10	9	17	11	10.4
20	14	20	14	25	19	18.4
22	25	28	19	30	28	26
24	34	45	31	43	42	39
26	47	65	45	61	56	54.8
28	60	80	58	74	78	70
30	74	94	80	91	100	87.8
32	89	117	92	101	124	104.6
34	111	137	101	119	143	122.2
36	131	155	119	129	165	139.8
38	148	177	130	142	180	155.4
40	178	204	158	165	192	179.4
42	197	230	180	178	209	198.8
44	220	243	208	191	215	215.4
46	238	256	217	215	229	231
48	251	271	227	226	238	242.6
50	256	275	237	238	249	251
52	267	285	246	246	255	259.8
54	273	295	261	244	266	267.8
56	278	298	265	246	272	271.8
58	281	306	272	253	273	277
60	291	308	275	255	283	282.4
62	294	317	272	254	288	285
64	305	321	272	252	291	288.2
66	317	324	269	254	291	291
68	326	332	276	254	289	295.4
70	331	338	276	262	287	298.8
72	330	335	276	262	284	297.4
74	327	332	277	267	285	297.6


400
350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
Test 1
Test 2
Test 3
Test 4
Test 5
Average

Results for 15 Cars:

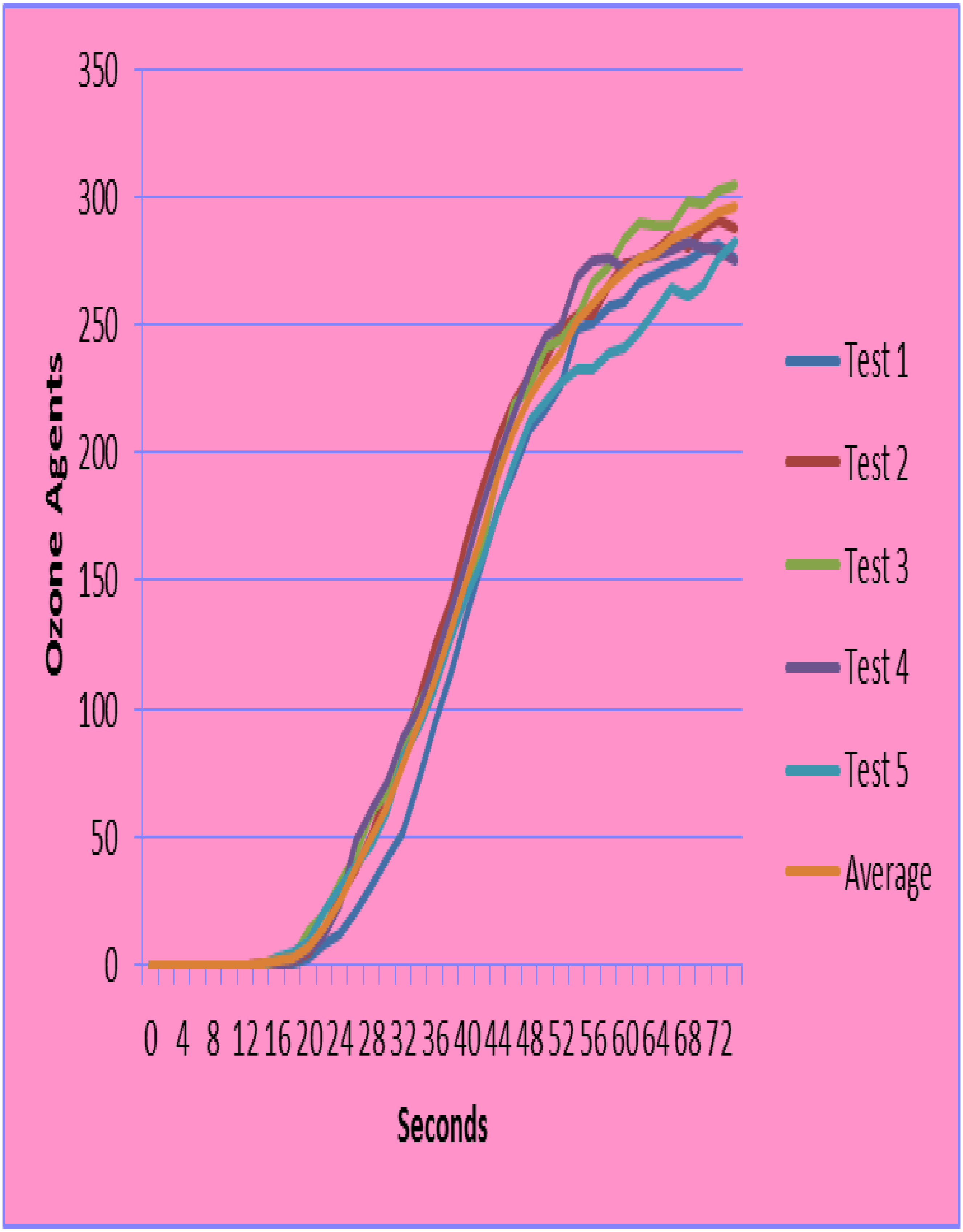
Secs	Test 1	Test 2	Test 3	Test 4	Test 5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	0	0	0
14	0	0	1	0	0	0.2
16	3	0	3	2	0	1.6
18	2	0	10	9	0	4.2
20	5	3	20	17	3	9.6
22	15	8	29	24	8	16.8
24	27	17	41	32	16	26.6
26	35	29	62	41	27	38.8
28	48	34	77	55	36	50
30	63	57	97	71	62	70
32	80	68	112	87	68	83
34	97	86	141	101	101	105.2
36	117	110	163	117	106	122.6
38	129	128	182	142	113	138.8
40	150	150	202	167	125	158.8
42	175	164	222	184	142	177.4
44	189	189	244	205	165	198.4
46	202	197	259	214	175	209.4
48	212	203	273	224	192	220.8
50	231	222	284	232	213	236.4
52	244	226	294	249	237	250
54	254	237	300	255	224	254
56	267	238	304	262	232	260.6
58	263	240	316	274	240	266.6
60	272	250	313	289	254	275.6
62	281	257	320	296	253	281.4
64	283	266	322	300	267	287.6
66	282	264	318	300	264	285.6
68	278	272	314	303	273	288
70	280	271	317	305	271	288.8
72	286	274	322	304	267	290.6
74	290	270	315	305	270	290



350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
Test 1
Test 2
Test 3
Test 4
Test 5
Average

Results for 10 Cars:

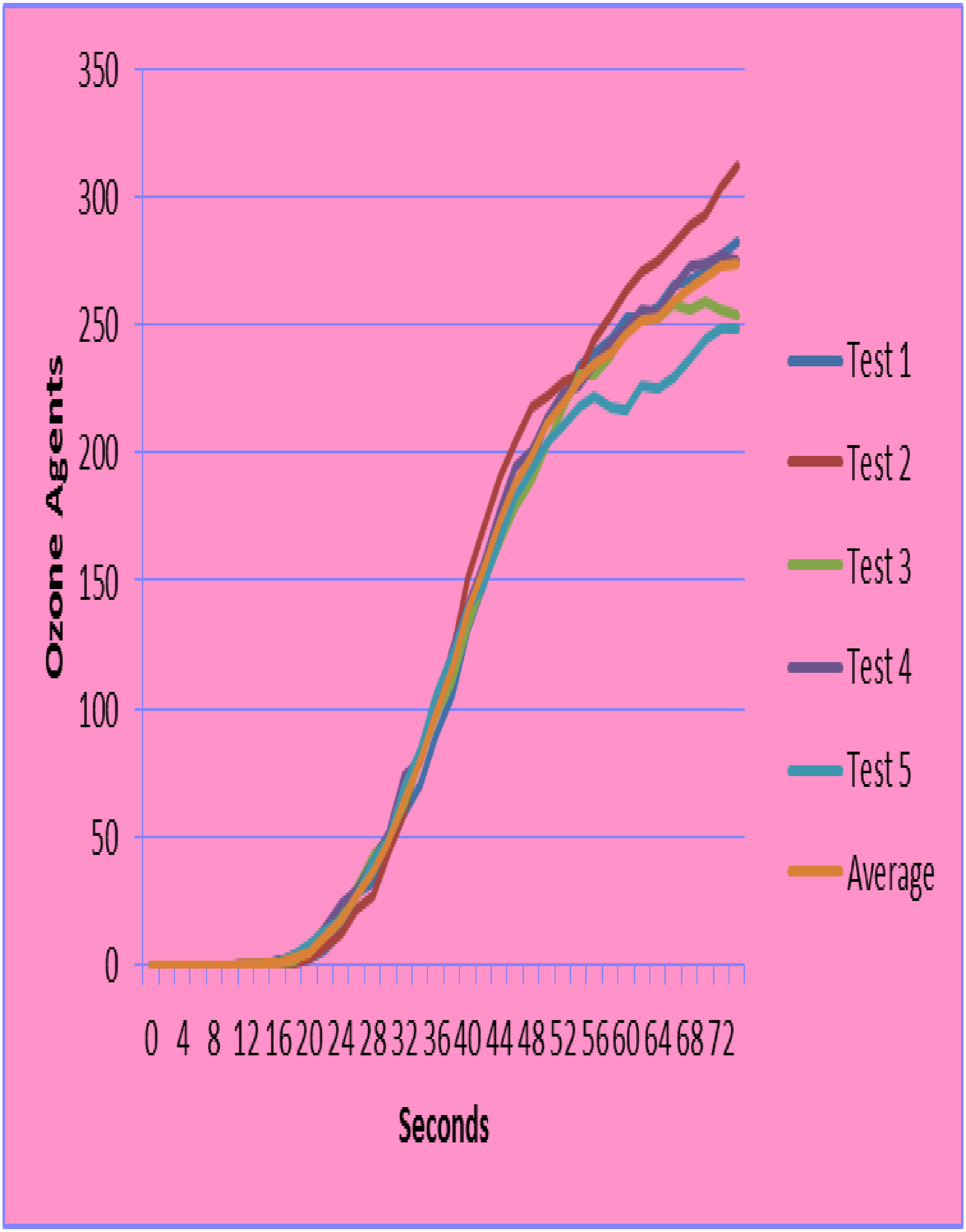
Secs	Test 1	Test 2	Test 3	Test 4	Test 5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	0	0	0
14	0	1	0	0	0	0.2
16	0	1	2	0	3	1.2
18	1	2	3	2	5	2.6
20	3	5	13	6	9	7.2
22	8	12	20	11	21	14.4
24	12	28	32	24	30	25.2
26	21	37	43	48	39	37.6
28	31	51	60	61	47	50
30	42	71	67	72	60	62.4
32	52	85	83	89	81	78
34	73	104	102	100	93	94.4
36	94	125	112	117	108	111.2
38	114	143	129	138	128	130.4
40	136	166	145	157	144	149.6
42	156	186	162	179	157	168
44	179	206	193	199	177	190.8
46	192	220	219	215	196	208.4
48	209	230	225	233	212	221.8
50	217	236	241	245	220	231.8
52	226	249	244	250	227	239.2
54	248	254	253	269	233	251.4
56	251	254	267	275	233	257.8
58	257	265	273	276	239	265.2
60	259	274	283	272	241	271.2
62	267	275	290	276	247	275.6
64	270	279	289	277	256	278.2
66	273	284	289	279	264	283
68	275	280	298	282	261	286.2
70	279	288	297	280	265	290
72	281	291	302	279	276	294.4
74	276	288	305	275	282	296



350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
Test 1
Test 2
Test 3
Test 4
Test 5
Average

Result for 5 Cars:

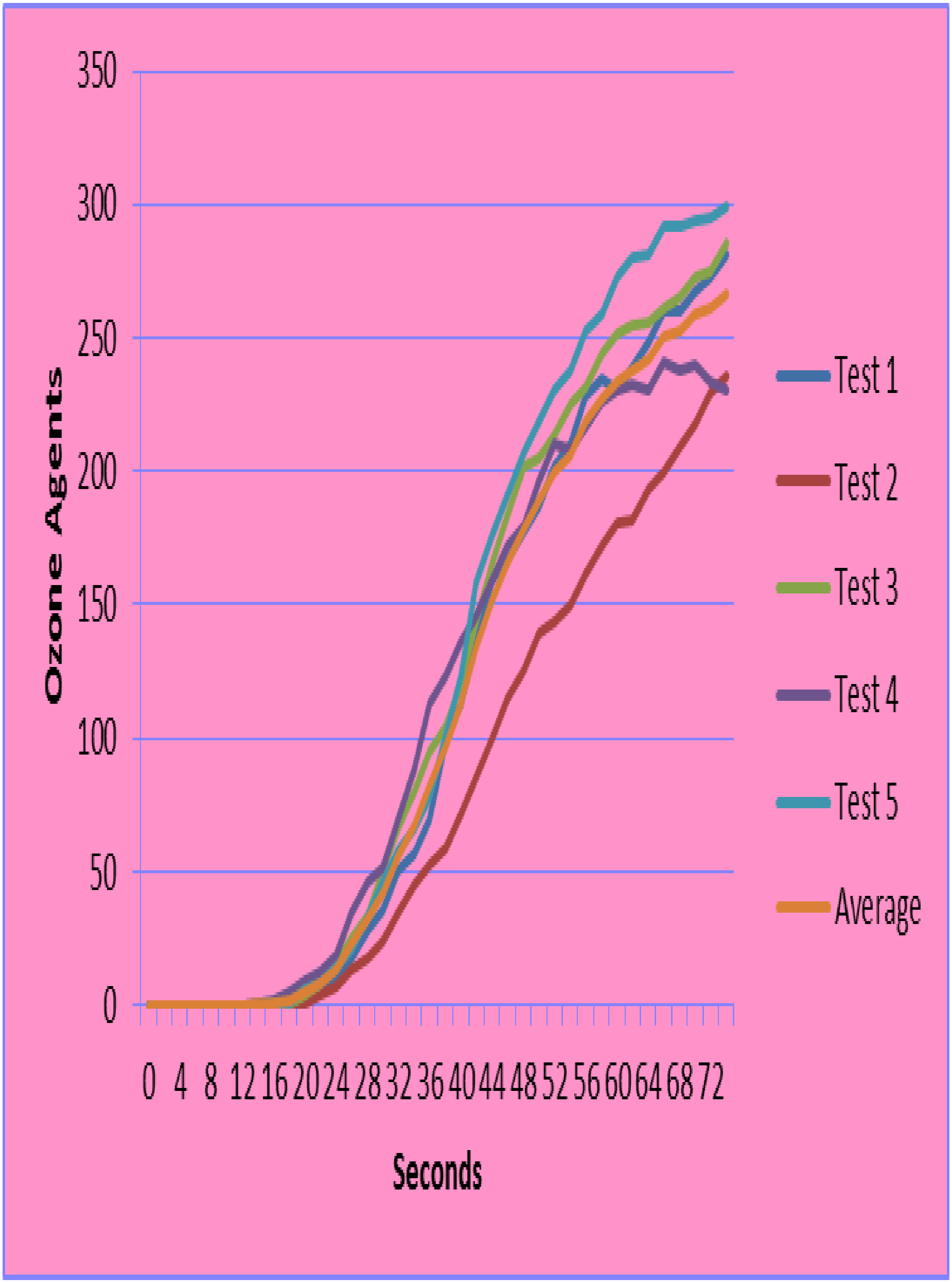
Secs	Test 1	Test 2	Test 3	Test 4	Test 5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	1	0	0.2
14	0	0	1	1	1	0.6
16	2	0	1	1	1	1
18	2	1	2	4	4	2.6
20	3	3	7	6	8	5.4
22	6	7	14	14	13	10.8
24	13	12	21	24	18	17.6
26	28	22	30	29	27	27.2
28	32	27	43	41	41	36.8
30	45	44	49	52	49	47.8
32	59	59	62	74	69	64.6
34	71	83	80	80	84	79.6
36	90	100	97	100	105	98.4
38	106	121	111	123	121	116.4
40	131	151	132	140	139	138.6
42	148	170	149	156	148	154.2
44	168	190	165	177	166	173.2
46	179	204	179	194	183	187.8
48	194	218	189	201	193	199
50	214	222	203	214	204	211.4
52	219	227	217	223	210	219.2
54	234	231	231	226	218	228
56	239	244	231	235	222	234.2
58	244	254	238	243	218	239.4
60	253	263	249	248	217	246
62	253	271	254	256	226	252
64	257	275	253	255	225	253
66	265	281	258	264	229	259.4
68	268	289	256	273	237	264.6
70	271	293	259	274	244	268.2
72	277	304	256	277	249	272.6
74	282	312	254	275	249	274.4



350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
Test 1
Test 2
Test 3
Test 4
Test 5
Average

Results for 0 Cars:

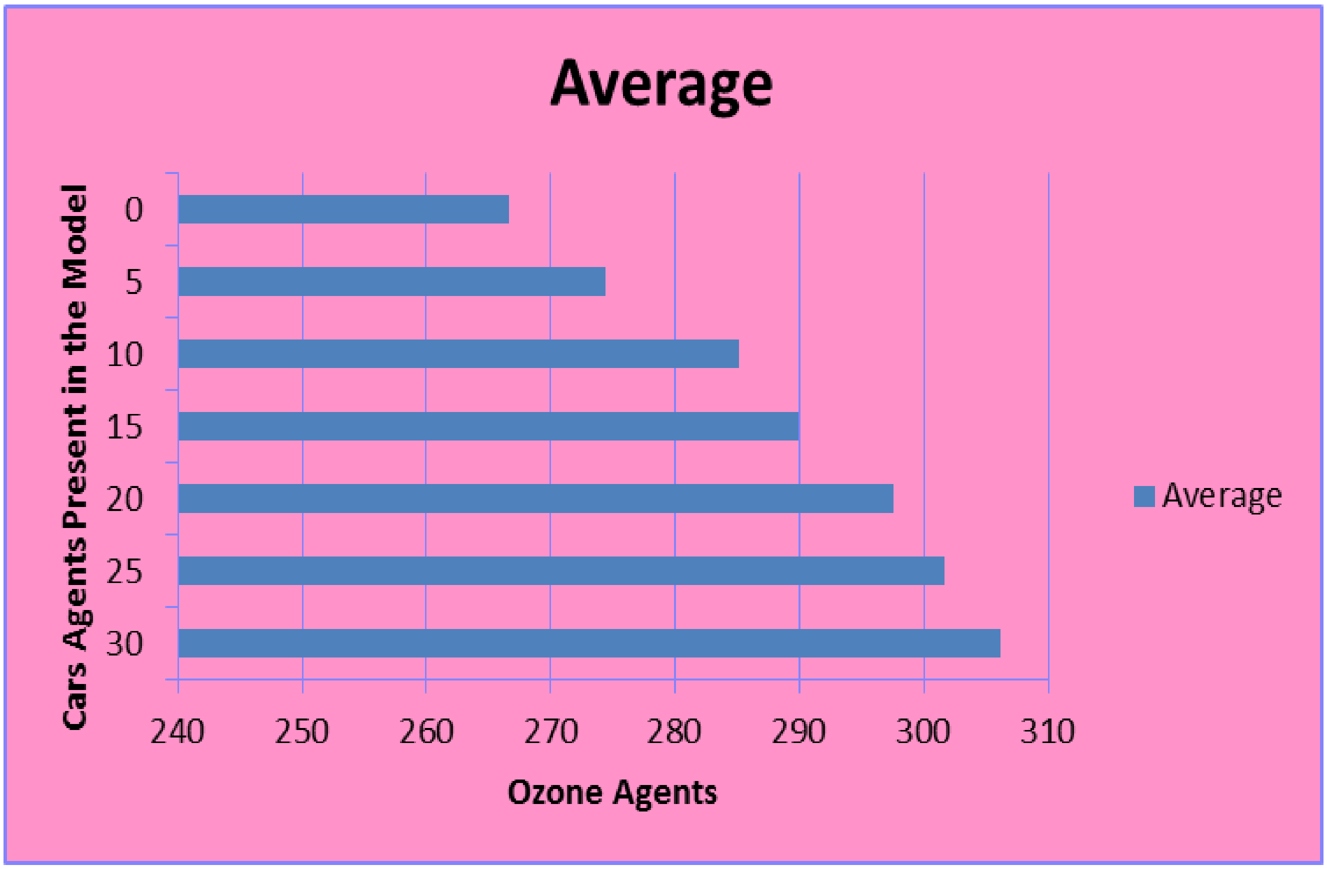
Secs	Test 1	Test 2	Test 3	Test 4	Test 5	Average
0	0	0	0	0	0	0
2	0	0	0	0	0	0
4	0	0	0	0	0	0
6	0	0	0	0	0	0
8	0	0	0	0	0	0
10	0	0	0	0	0	0
12	0	0	0	0	0	0
14	0	0	0	1	0	0.2
16	1	1	0	2	1	1
18	2	1	1	5	1	2
20	3	1	4	9	6	4.6
22	6	4	8	12	8	7.6
24	10	7	16	19	14	13.2
26	18	13	25	35	21	22.4
28	28	18	34	46	34	32
30	36	24	50	52	46	41.6
32	50	35	66	69	58	55.6
34	57	45	80	89	66	67.4
36	70	53	95	113	78	81.8
38	99	59	104	124	101	97.4
40	113	72	120	136	124	113
42	136	85	144	146	158	133.8
44	160	100	166	159	176	152.2
46	167	115	184	172	191	165.8
48	178	126	202	180	207	178.6
50	187	139	205	197	219	189.4
52	202	144	214	210	231	200.2
54	210	150	225	208	238	206.2
56	228	162	232	217	253	218.4
58	235	172	244	226	259	227.2
60	231	181	252	230	273	233.4
62	239	182	255	233	280	237.8
64	249	193	256	231	281	242
66	260	200	261	241	292	250.8
68	260	209	265	238	292	252.8
70	268	218	273	240	294	258.6
72	273	229	275	234	295	261.2
74	281	236	286	231	299	266.6



350
300
250
200
150
100
50
0
Ozone Agents
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72
Seconds
Test 1
Test 2
Test 3
Test 4
Test 5
Average

Averages for All Sets:

Cars	Test 1	Test 2	Test 3	Test 4	Test 5	Average
30	327	308	295	294	307	306.2
25	302	290	291	311	314	301.6
20	327	332	277	267	285	297.6
15	290	270	315	305	270	290
10	276	288	305	275	282	285.2
5	282	312	254	275	249	274.4
0	281	236	286	231	299	266.6



The first five tests of my model dealt with 30 greenhouse gas emtting Cars agents. I had expected that when I replace more of those Cars Agents with Green Cars, there would be fewer Ozone Agents produced, because of the decreased number of nitrogen oxides and carbon monoxides in the model. My prediction was correct. As I lowered the number of normal Cars and increased the number of Green Cars, there was a decrease in tropospheric ozone.

Conclusion:

To decrease pollution and ozone levels in the atmosphere, we have to switch to other means of transportation, such as greener cars that produce less greenhouse gases than the cars that we normally drive today. My model and results suggest these rules exactly. If we are to decrease the ozone in the atmosphere then we will have to switch to other transportative methods such as public transportation, car pooling, and of course driving greener cars. I believe that my achievement in this project would be creating the model itself, to model that if we decrease the number and/or type of cars that we drive, we could not worry about tropospheric ozone at all. If we want to save the people of future Albuquerque from the harmful effects of ozone, the time to change is now.

Recommendations:

I had originally planned on adding more procedures to my model, but I did not have time to do some of these things. I had planned on adding real data concerning car emissions of nitrogen oxides and carbon monoxides. Other things that I could have added to the model are:

- Making it more like a place in Albuquerque, with surrounding mountains.
- Chemical reactions don't occur all the time, so having them occur sometimes.
- Do different seasons such as winter or summer
- See the difference in ozone levels between weekdays and weekends.

Acknowledgements:

I thank Mrs. Sagartz and Mr. Davis for assissting me with creating this model.

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