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Original Research Article

The study of an increment of air pollution over a coastal city

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Keywords

Pollution, Industrial areas, Transport activities, Combustion and Trends.

A B S T R A C T

The major aim of this study is which the main sources of increases pollution are continuous over the Visakhapatnam area and how it has been facing the problems. In this study, we consider that how the pollution concentration increase from the industries and vehicular trend is observed since last 15years. We observed the traffic volume at a major traffic intersection and at midway intersections along with time. Here we consider that most of the industries are using crude oil, coal etc., the expected gas emissions from stationary point sources are SPM, SO2 and NOx, which are due to the combustion of coal, furnace oil and diesel. During the process heating, SO_2 and NO_X are released due to Combustion of fuels to maintain reaction conditions. The pollution load from the industries in the bowl area and traffic volume data clearly points out that not only industry but also traffic is also a source of air pollution.

Introduction

Unpleasant fumes and odors, reduced visibility, injury to human health, crops and forms of vegetation by noxious pollutants and damage to property by dust particles and corrosive gases rank among the major environmental problems of urban and industrialized areas and their surroundings.

The fact was true with Visakhapatnam (17°42'N; 82°18'E) a highly industrialized coastal metropolitan city on the east coast of India.

Physiography

The physiography of Visakhapatnam exhibits distinctly three broad relief features i) The two hill ranges forming the northern (Kailasa range) and Southern (Yarada range) borders ii) The waltair highlands extending along the shore iii) Extensive tidal swamp on the west and iv) Bay of Bengal on the eastern side. Fig. 2.1 collected during April 86 through LANDSAT 5 makes one clear of the environment of Visakhapatnam and fig 2.2 is the graphical representation of the study area i.e. Visakhapatnam.

The Kailas range (Northern hill range) is about 16km long rises abruptly from the seashore and gradually extends westwards culminating in its central highest part of Thomas Folly (506m). Thereafter, it gradually decreases westward. The headland, projecting to the East into the Sea

(Rushikonda) has been separated from the range by a gap through which flows a stream known as Hanumanthavaka Gedda. Thus, except at this gap, the hill range forms an inaccessible natural boundary.

The Southern hill range known as Yarada also forms an inaccessible boundary running for about 8km., from the shoreline in the East-West direction. The headland projects boldly into the sea and forms a cliff. After the shape of its projection it is known as Dolphins nose. The height of the range gradually increases eastward attaining its maximum at Yarada Konda (358m). Its height decreases westward and ends abruptly.

1) KAILASA HILL RANGE
2) YARADA HILL RANGE
3) SMALL HILLOCKS ON WEST
4) "BAY OF BENGAL"- SEA ON EAST

The Waltair high lands are elongated for 6km, from South-West to North East along with sea shore. They have assumed a triangular shape in between the sea and the swamp. The steep rise of the Waltair uplands above the low and rolling surface of the Southwest, starts from the sand hill with an elevation of 50m and gradually raises northeastward culminating in the central part of rock-house (84m) and thereafter decreasing gradually north-eastward.

Visakhapatnam as a coastal zone with potential pollution source points

Visakhapatnam was a small town at the beginning of this century became a major port city due to developments like establishment of Chennai Howrah rail-line, Port based activities, commissioning of Hindustan Shipyard, Naval base and other major industries and also educational Institutions. Visakhapatnam is one of the highly industrialized centers in the state of Andhra Pradesh.

Industrial development is at its peak in Visakhapatnam district and it is partly due to port-based export and import nativities. There are several major industries like Visakhapatnam Steel Plant (VSP), Hindustan Petroleum Corporation Ltd. (HPCL), Coromandel Fertilizers I Id (CFL), Bharat Heavy Plates and Vessel Ltd., (BHPV), Hindustan Zinc Ltd. (IIZL), LG Polymers Ltd., and lots of other ancillary industries. Business and trade have also contributed to the rapid growth of Visakhapatnam district. Some more industries are planning to establish their production units in this area. Greater Visakhapatnam Municipal Corporation area extends over a urea of 540 Sq.Km including Visakhapatnam rural area.

This rapid industrialization has simultaneously increased urbanization in this city. The growth of population is also rapid and now Visakhapatnam is the second largest city in Andhra Pradesh, India population wise The Fig. 2.3 explains the population growth in the city.

Hindustan Petroleum Corporation Limited

Hindustan Petroleum Corporation Limited (HPCL) has a crude processing capacity of 7.5 million metric tons (mmt) per annum. During the year 2001-2002, the industry processed 6.7 mmt of crude. The main products /.ire diesel, motor spirit, kerosene, aviation turbine fuel, LPG, naphtha and bitumen; with average production of 219.4, 57.3, 500, 2.3, 9.4 and 9.1 thousand metric tons (tmt) per annum respectively. In the refinery main Processing units are crude distillation,

vacuum distillation, fluid catalytic cracking, bitumen blowing, sulfur recovery and merox units. Apart from the, above there are four utility boilers, two CO boilers and four heat recovery-steam generating units which are used in process units.

In the distillation and other fractionation units, different types of fuels, liquid or gas are used for the purpose of the process heating, which are generated internally. Usage of fuels depends on the availability as well as requirement. Details of process units and type of fuel consumed and release of pollutants are shown in Table 2.1. Generally fuel oil, naphtha, low sulphur heavy stock (LSHS) and fuel gas are used in the refinery. There is a sulphur recovery unit (SRU) to desulphurise the fuel gases and off, gases which, are generated in amine unit and sour water stripper. Main purpose of SRU is to reduce the overall SO_2 emissions from the refinery. A part of process and sulphur recovery units, there is a flare stack where in lean gases of CO and organics are burnt. Therefore, the expected pollutants from refinery due to burning of different types of liquid and gaseous fuels are SO_2, SPM and NO_X and also there are incombustible products such as CO and Hydrocarbons, which are released through the process/operating units as fugitive emissions.

Coromandel Fertilizers Limited

Coromandel Fertilizers Ltd. (CFL) is in operation with a capacity of 2000 tons per day (tpd) of various types of fertilizers. It produces various fertilizer grades of GROMOR 28:28:0, 14:35:14 and 20:20:0 ammonia (NH_3), urea and phosphoric acid respectively. This industry has mainly three plants viz, sulphuric acid plant, phosphoric acid plant and complex fertilizer plant. Previously it was used to produce ammonia and urea internally for captive consumption. At present CFL is getting both ammonia and urea from outside, Suppliers to produce complex fertilizers. HPCL supplies LSHS which is used as fuel in the industry.

Sulfuric acid plant: The plant has a capacity to produce 1200 tons of sulphuric acid (H_2SO4) per day with an average working capacity of 1130 tpd. Liquid (molten) sulfur is burnt with air to produce SO_2 and is then converted to Converter. The SO_3 is then absorbed in absorption towers to produce 94% Concentrated acid. SO_2, SO_3 and acid mist is the main emissions during the process. Absorption tower and brick mist candles are used pollution as lion control equipments.

Phosphoric acid plant: This plant produces 400 tpd of Phosphoric acid in the form of 30% acid based on dehydrate process. Rock phosphate is grinded mill and is digested with sulfuric acid to produce phosphoric acid and gypsum. The slurry is filtered to separate the solid gypsum from the acid. The acid, concentrated in vacuum evaporators to produce 48% acid for use in complex plant. Packed bed fume scrubber is used to control fluorine emissions. Hence expected emissions from this unit include fluorine and acid

Complex plant: The .complex plant presently consists of three trains viz. 'A' ‘B’ and' *C* to produce 650, 650 and 700 tpd respectively. In the case of 28.0 ammonia, phosphoric acid and sulphuric acid are made to react in an agitated tank reactor. The slurry is granulated in a rotary Granulator for further ammonization. The granules are dried in a rotary dryer, screened and the product is sent to the bagging plant. Fumes from the reactor and granulator are scrubbed with weak acid in a series of scrubbers.

With a capacity of 750 mtpd is added in June2000 to produce 20:20:0 and 14:35:14. In this stream, ammonia, sulfuric acid, phosphoric acids are reacted in a pipe reactor. The product is dried, screened cooled and sent to bagging plant. NH_3, SPM and fluorine are released during the process.

LP steam boilers are working by utilizing waste heat generated in the plant. The expected pollutants from the sulphuric acid plant are SO_2, SO_3 and sold mist, while phosphoric acid plant releases fluorine and acid mist whereas fluorine and SPM are emitted from complex plant. In captive power generation unit, LSHS is used as a fuel, resulting in emissions of SPM, SO_2 and NOx

Andhra Petrochemicals Limited

Andhra Petrochemicals Limited (APCL) produces 2 ethyl hexanol, normal butanol and isobutanol with an overall capacity of 39,000 tons per annum (tpa).

Different types of gases or liquid fuels are used for process heating in this industry. Purge gas and Oxo residue are internally generated while remaining liquid fuels are obtained from HPCL. For this plant, major requirement is synthesis gas which is produced internally. Raw materials used in the industry (on average basis) are 930 tons of naphtha per month (tpm) and 2610 tpm of propylene.

Synthesis gas preparation and hydrogen production

naphtha is super heated to reaction conditions, which is reformed in two stages. The reformed gases are passed through carbon dioxide removal section. After extracting pure hydrogen in PSA unit, remaining gases are thoroughly mixed with a portion of reformed gases and compressed. During the process heating, SO_2 and NO_X are released due to Combustion of fuels to maintain reaction conditions.

LP Hydro formulation of propylene to Aldenydes: APCL produces iso-bulyraldehyde and normal butyraldehyde in an Oxo reactor in which propylene is received from HPCL as main raw material.

Alcohol plant: In alcohol plant, a single stream hydrogenation and refining system is used at different times to produce separately three desired alcohol products i.e. 2-EH, N-butanol and isobutanol for which internally produced, N-butyraldehyde and isobutyraldehyde are used as raw materials. Apart from these, there are diesel generators, reformer and fired heaters which are also considered as sources of SPM, SO_2 and NO_X. Gases) i.e. *hydrocarbons* (HC) emanated from storage tanks, pressure control systems and safety valves discharge HC as fugitive emissions.

Rain Calcining Limited

Rain Calcining Limited produces mainly Calcined petroleum coke at a rate of 20,833 tpm, wherein green petroleum coke of 33840 tpm is used as a Raw material for the process. In this plant 1755 tpm of LSHS is used as a fuel along with coke fines. There is also a captive power plant with a capacity of 49.5 MW, using steam generated from waste heat recovery boiler (WHRB) and circulating fluidised bed boiler (CFBB). Main source of air pollutionhesis gas, nap in this is WHRB, which was installed at the outlet of calcination unit. As LSHS is used in calciner, flue gas consisting of SPM, SO_2 and NO_X are released through the outlet of gas suspension absorber (GSA)

followed by bag house and flue gas desulphurization (FGD) unit connected to CFBB. Apart from these sources, particulates will be emitted through auxiliary boiler, crusher house, bucket elevator and dry bin stack.

Hy-Grade Pellets Limited

The plant has a capacity to produce 10,000 tpd of high grade iron oxide pellets using iron ore and limestone as raw material. The process involves wet grinding, thickening, slurry separation, additive grinding, mixing and palletizing followed by indurating. LSHS of 130 klpd is used as a fuel in the process. Hence it is a main source of SO_2 and NO_X emissions apart from SPM. From other remaining sources expected pollutant to be only dust (SPM).

Aluflouride Limited

It has a capacity to produce 15 tpd of aluminium fluoride by using hydroflourosilicic acid and aluminium hydrate of 18 tpd as main raw material. The source of air emissions is process units, steam boilers, hot air generators (furnace) and standby power generators. For process heating as well as steam generation, furnace oil (5 klpd) is used as fuel whereas diesel is used for standby generators. Hence the expected emissions are SPM, SO_2 mid NO_X. In this plant, apart from flue gas emissions, a possibility of aluminium based fluoride dust is expected from process unit.

LG Polymers Limited

Main product from this plant is polystyrene, which is produced in batch

Process using styrene as basic raw material. The plant is in operation with a capacity of 211 tpd. At present, there are two utility steam boilers with a capacity 8 tpd each, two oil fired heaters and five diesel generators. Total consumption of furnace oil is 8 tpd while LSHS is 53 tpd which are obtained from HPCL/IOC. The expected pollutants are flue gas emissions consisting of SO_2, NOx and to some extent particulate matter.

Visakhapatnam steel plant

Visakhapatnam steel plant is located at Parawada and it is at a distance 15 km from the bowl area. The installed capacities of hot metal, liquid and salable steel in million tons per annum (mtpa) are 3.4, 3.0 and 2.6 respectively. On an average 3770 tpd of coal, 16.33 klpd of diesel and 3.86 kind of furnace oil are consumed in the plant. Apart from these fuels, in plant generated gaseous fuels of 19.93 million m3/d and coal tar fuel of 89 and coal are also used. Total installed capacity of the plant is 21.56 mtpa including Intermediates whereas quantity produced during the year 2001-2002 was 26.56 mtpa, while in 2002-2003 it is 21.86 mtpa. During the process, there are secondary products, like slag and coke products. Particulate emissions are mainly from boiler stack of TPP (Thermal Power Plant), melting shops, coke oven batteries, blast furnace and sintering plant. Apart from coal, furnace oil and diesel consumption is around 10 tpd. Hence consumption of coal is considered as the major source of SO_2 emissions in steel plant.

Materials and Methods

In this study, observed the air pollution concentrations over a Visakhapatnam Industrialized city. The data were collected from the different Industries along with those releasing gases and numbers of vehicles have been increased from last 15 years according to the AP Trance port survey. The industrial

areas are HPCL, Coromandel Fertilizers Limited, Sulfuric Acid Plant, APCL (Andhra Petro Chemical), Alcohol Plant, Rain Calcining Limited, Hy-Grade pellets and Visakhapatnam steel Plant. Another important source is increasing of number of vehicles and their usage. Here we consider the vehicular increment from the last 15 years and their cross section areas with respect to time those are Asilmetta road, NAD X- road, Gajuwaka, Convent Junction, Jagadamba, Thatichetlapalem, Sriharipuram Airport Highway and Novel Dockyard. The observing parameters are SO2, NO2, TSPM, and RSPM. Not only industry but also traffic is also a source of air pollution.

Results and Discussion

Now a day's Visakhapatnam city facing the major problem of air pollution due to increasing no. of pollution sources such as industries, vehicular usage and mainly the city is located in coastal areas. There is one of the region to increase the pollution is it has the complex terrain. In this study, we consider that how the pollution concentration increase from the industries and vehicular trend is observed since last 15years. We observed the traffic volume at a major traffic intersection and traffic volume at midway intersections along with time.

Observed traffic volume stations are Asilmetta road, NAD x- road, Gajuwaka, Convent junction and Jagadamba. Two wheelers are mainly dominated in all hours and all these stations. In Asilmetta Road two wheelers are higher noticed in 10 to 12, 16 to 18 and 18 to 20hrs. Three wheelers (Autos) using time is started from 8 to 10 hrs continuously, because of the schools and colleges timings. In this road 4 (LCV) are reached greater percentages than 4(HCV). Two wheelers are highly noticed over NAD X-road in all hours when compared with Asilmetta road, but three wheelers are less noticed than Asilmetta and again 4 (LCV) is high in NAD – X road. In Gajuwaka area 2 wheelers are highly noticed from 10 to 16 hrs after that little bit decreasing from 16 to 22 hrs continuously. But here 4 (LCV) is greater used than 3 wheelers perhaps it is along with the industrial area. Convent Junction in this area from 16 to 18hrs 2 wheelers are highly used by humans, because of there is a railway station and some of the markets are located. 3 wheelers are also highly noticed than Gajuwaka in all times because of transportation.

4 (LCV) vehicles are highly used in 8 to 18hrs and 4(HCV) are in 8 to 10hrs. In Jagadamba 2 and 3 wheelers usage are continuously increasing from 6 to 12hrs, because of transport is high towards surrounding areas such as RK beach, Railway station and Shipyard. 4(LCV) vehicles are highly used from 18 to 20 hrs in Jagadamba area.

Traffic volume at mid way intersections also observed. Airport highways, in these area 2 wheelers are highly crossed in the morning 8 to 10hrs and 14 to 20hrs. But in 12 to 16 hrs are very less noticed. Here 4 (LCV) are highly noticed greater than 4(HCV) and 3 wheelers in all times. In the Navaldock yard area 2 wheelers are highly used along with 6 to 8hrs which is greater than all stations. 4(LCV) and 4(HCV) are reached the same with little bit variations, 3 wheelers are highly noticed in 8 to 10hrs and 16 to 18hrs.

In Thatichetlapalem area 8 to 12hrs and 16 to 18hrs are noticed that two wheelers are maximum crossed in this time period and 4(LCV) are highly noticed in 18 to 20hrs and 20 to 22hrs.3 wheelers usage is continuously increasing from 6 to 8 hrs up to 14hrs and again decrease 16 to 22hrs.

Table.1

Stack Details	Point Sources		Velo (m/s)	Temp (^{0}C)	Pollutant Load (g/s)				
	Stack ht (h)	Dia (m)			SPM	SO2	NOx	HC	CO
CDU-I, 2F1	60	1.4	10	176	0.39	4.56	0.58	-	-
CDU-I, 2F4	60	1.6	5	160	0.23	3.14	0.27	-	-
CDU-I, 2F2	60	1	9	176	0.25	2.2	0.25	-	-
CDU-II, 11F1	60	2.55	3.44	281	0.74	14.88	2.39	1.03	0
CDU-II, 12F1	60	1.6	3.61	180	0.44	2.51	0.98	0.15	0.025
CDU-III, 42F1	60	2.74	2.32	138	0.78	29.7	2.02	0.58	0
CDU-III, 42F2	60	1.59	2.35	171	0.23	6.83	0.68	1.36	0
VBU,46F1	60	1.89	5	160	0.3	8.11	2.84	-	-
F FCCU-I,4F51	60	2.18	1.45	242	0.29	3.78	0.61	5.68	0.019
FCCU-II,14F1	60	1.35	3.3	241	0.28	4.36	0.92	0.13	0.054
BHPV	60	1.74	3.49	196	0.56	0.41	0.21	0	0.028
WIL - 8	60	2.25	3.47	214	0.61	1.85	0.73	0	0
WIL –A/B	60	2.25	2.46	296	0.45	2.35	4.00	1.77	0.045
FCCU-I, Co boiler	60	1.6	1.9	136	11.57	19.67	5.33	-	-
FCCU-II, Co boiler	80	3.03	2.1	188	-	4.08	3.14	4.52	0.069

Table.2 Pollutants Load from Major Industries in Visakhapatnam Bowl Area

HRSG-I	60	2.4	2.45	152	0.09	0.29	0.87	0	0
HRSG-II	60	2.4	3.08	104	0.09	0.52	0.68	0	0
HRSG-III	60	2.4	16.52	141	0.37	1.72	4.71	0.08	0.08
HRSG-IV	60	2.4	17.04	142	0.46	0.92	4.47	20.49	2.21
PDSH,62F1	35	0.87	0.75	403	5.00	0.2	0.15	-	-
DHDS,60F1	60	1.34	4.38	205	0.25	7.9	4.82	3.35	0
SRU,65F1/65 X1	60	1.21	19.39	210	-	47.86	4.82	27.76	9.96
REFORMER, 61F11	60	1.6	8.3	407	113.00	0.61	4.72	-	-
				Total (g/s) (t/d)	136.38 1.78	168.45 4.55	50.19 34	66.91 78	12.49 1.08

*= Acid mist

Table.3 Number of Vehicles that crossed 15 years in Visakhapatnam District

Name of the Vehicle	NO. of Vehicles	No. of Vehicles Crossed 15 Years
Autos	65,648	22,157
Goods vehicles	56,925	3,584
Vehicles of Educational Institutions	2,374	765
Jeeps	4,543	2,480
Motor Cycles	6,50,130	2,30,064
Mopeds(TVS)	3.879	1,782
Cars	1,23,002	23, 992
Total Vehicles (Including others)	**9,06,501**	**2,84,824**

Table.4 Transport activities at intersections: Visakhapatnam

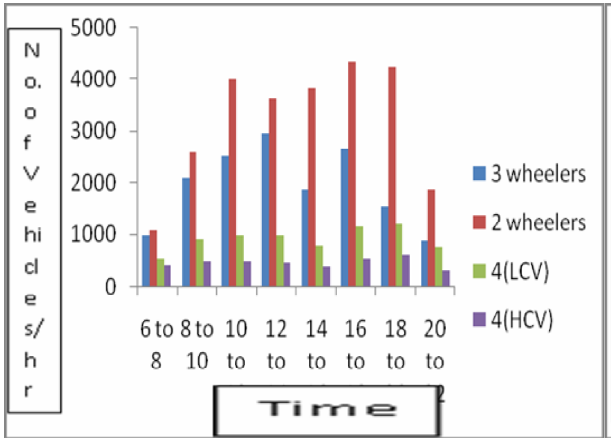
Hrs	Asilmetta				NAD X Road				Gajuwaka				Convent Junction				Jagadamba			
	Wheelers				Wheelers				Wheelers				Wheelers				Wheelers			
	3	2	4 (LCV)	4(HCV)	3	2	4 (LCV)	4 (HCV)	3	2	4 (LCV)	4 HCV)	3	2	4 (LCV)	4 HCV)	3	2	4 (LCV)	4(HCV)
6 - 8	994	1080	550	421	677	1651	430	385	297	642	218	211	448	781	211	312	442	470	211	188
8-10	2088	2589	911	493	1285	3215	789	554	565	1288	585	385	775	1411	485	457	1285	1325	600	166
10-12	2531	3985	985	486	1586	3091	1058	612	652	1314	779	445	575	1345	549	388	1245	2283	576	175
12-14	2945	3611	986	478	1445	3141	911	489	688	1917	642	488	636	1345	581	425	1247	2075	685	197
14-16	1875	3814	793	387	1064	3148	1193	675	786	1958	645	393	601	1211	541	356	1279	2613	645	211
16-18	2671	4347	1147	543	1379	3486	1287	789	511	1576	719	444	679	1712	411	293	1561	2657	686	231
18-20	1545	4245	1209	611	1385	3085	1476	585	511	1483	669	388	533	1296	399	219	1488	2756	925	188
20-22	883	1884	775	323	896	2047	884	448	359	1022	601	342	396	904	353	189	1475	2216	711	211

Table.5 Transport Activities in Midtracks: Visakhapatnam

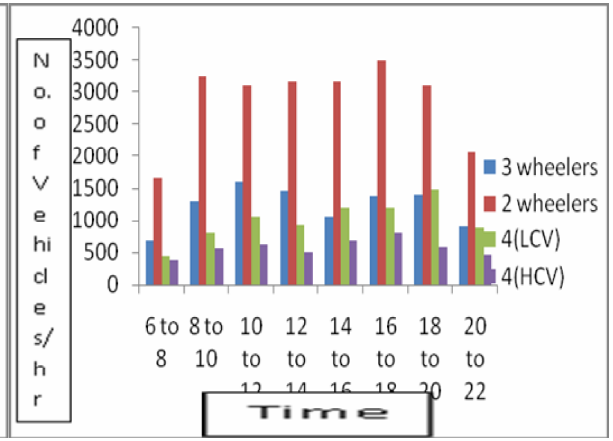
Hrs	Airport highway				Naval dockyard				Thatichetlapalem				Sriharipuram			
	Wheelers				Wheelers				Wheelers				Wheelers			
	3	2	4 (LCV)	4(HCV)	3	2	4 (LCV)	4(HCV)	3	2	4 (LCV)	4(HCV)	3	2	4 (LCV)	4(HCV)
6 - 8	411	1201	475	388	411	2377	845	601	574	1077	669	475	441	988	313	258
8-10	711	2377	1086	542	598	1201	998	711	727	2250	911	475	611	1566	473	271
10-12	887	2256	911	514	315	868	699	681	1045	2259	989	344	564	1256	356	387
12-14	567	1771	1112	558	284	767	767	671	1045	2178	786	386	575	1369	344	475
14-16	669	1894	1055	548	312	1274	601	455	874	1842	1314	581	565	1365	399	411
16-18	723	2584	912	55	587	2098	755	548	1137	2618	1372	513	555	2279	501	401
18-20	656	3045	1068	486	396	1711	767	448	955	2468	1701	797	665	2045	587	323
20-22	398	1415	865	311	372	897	796	512	965	1999	1376	669	575	1422	691	357

Traffic volume at major traffic intersections at Visakhapatnam bowl area

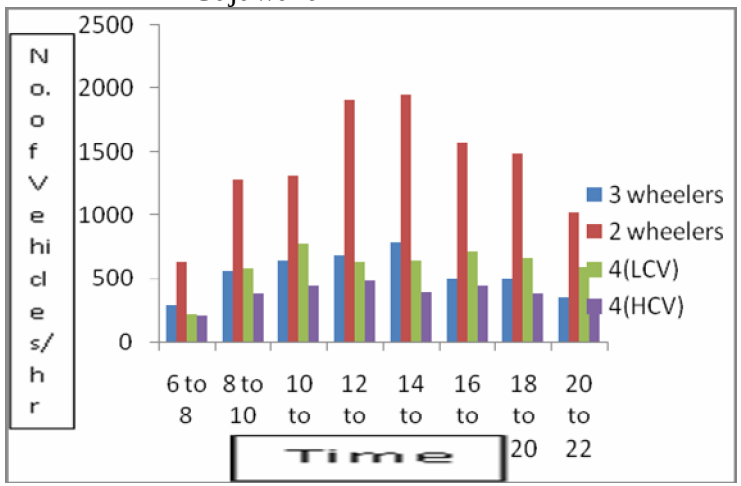
Asilmetta Road



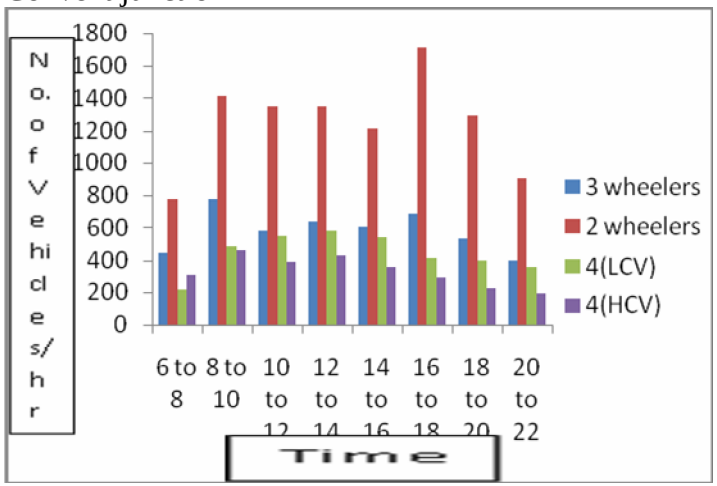
NAD –X Road



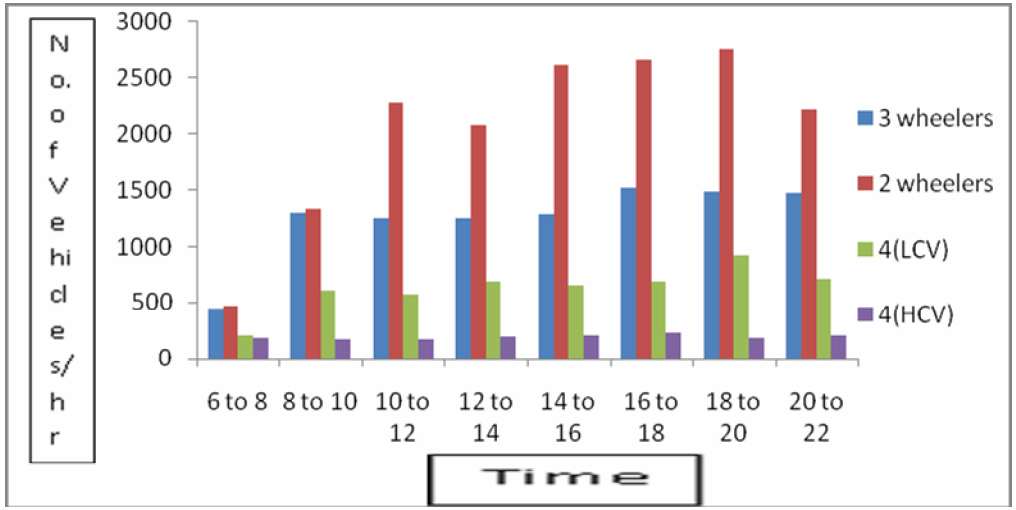
Gajuwaka



Convent junction

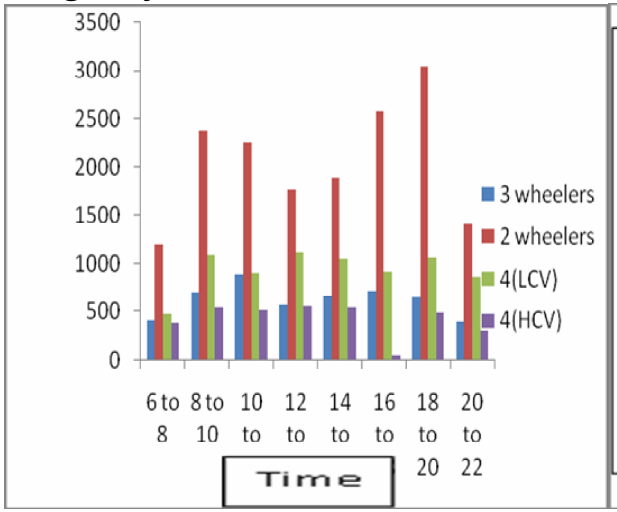


Jagadamba

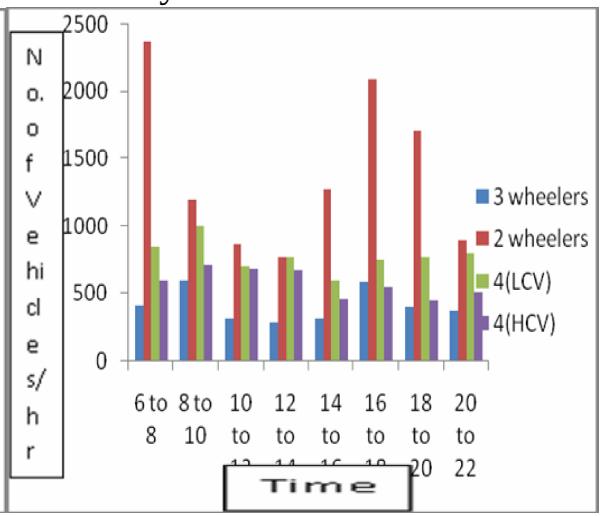


Traffic volume at mid way intersections at Visakhapatnam bowl area

Airport Highway



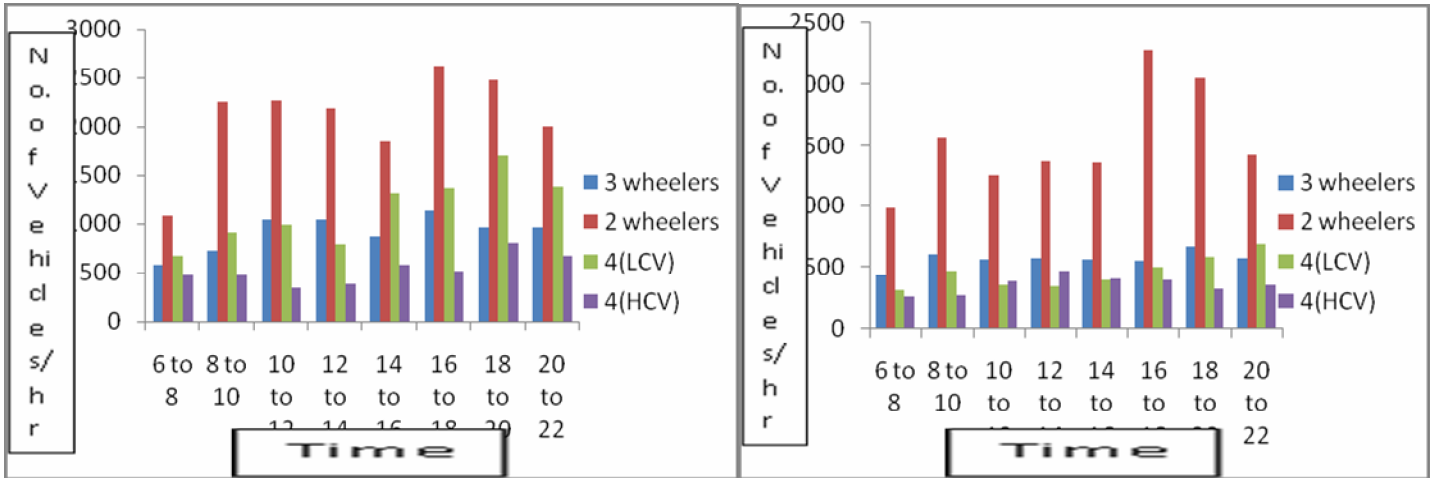
Naval Dockyard



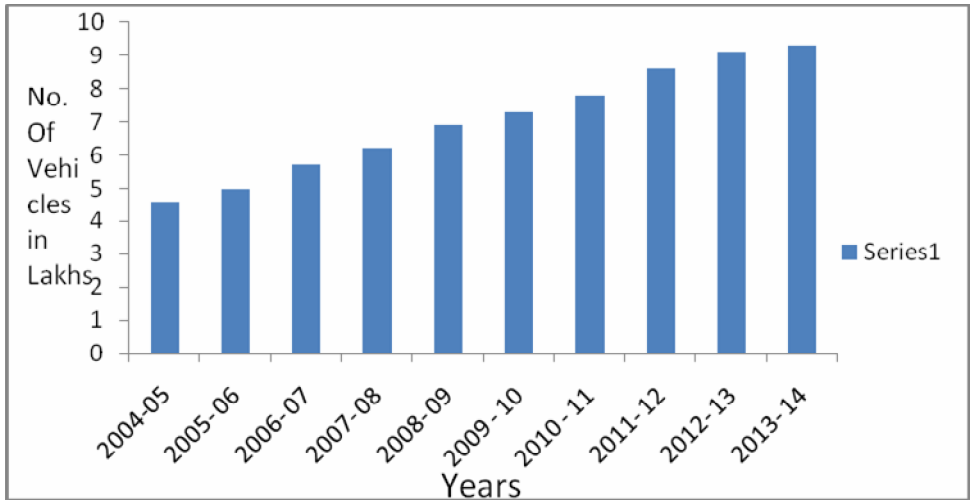
No. of Vehicles/hr

Thatichetlapalem

Sriharipuram



Time Trends of No. of Vehicles



In Sriharipuram area two wheelers are reached the highest percentage in 16 to 20hrs. 3wheelers are very less and reached same percentage in all timings from 8 to 22hrs. 4(LCV) are high in 20to 22hrs than all hours. Here, finally we consider the time trends of no. of vehicles within the last 10years, which is continuously increasing in lakhs.

Special emphasis is given to Visakhapatnam because of its geographical setting with complex terrain. Being a coastal zone, the city is attached to multinational projects and consequently this resulted not only in rapid industrialization and simultaneously urbanization but also increase in pollution. The population growth and the increase in vehicular traffic are causing environmental pollution in general and air pollution in particular. The pollution load from the industries in the bowl area and traffic volume data clearly points out that not only industry but also traffic is also a source of air pollution.

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