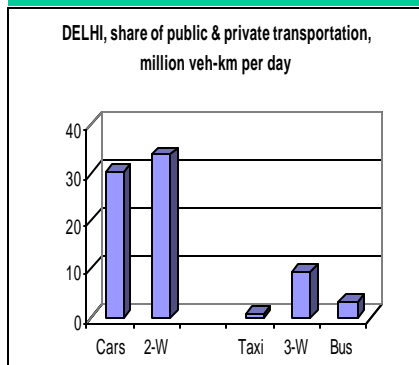


EFFORTS TO REDUCE POLLUTION FROM 2 WHEELERS IN INDIA AND ACROSS ASIA

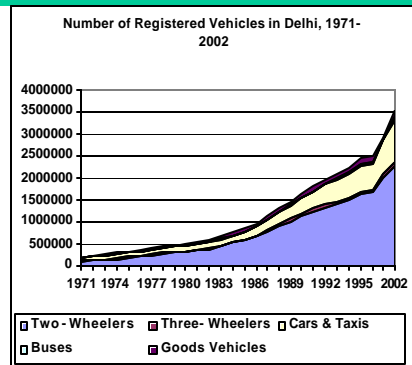
**Narayan Iyer,
Bajaj Auto Ltd, Pune, India
Better Air Quality Workshop 2002
Hong Kong, 16 - 18 December 2002**

RAPID INCREASE IN THE REGISTRATIONS OF TWO WHEELERS IN ASIAN CITIES - EXAMPLE OF DELHI



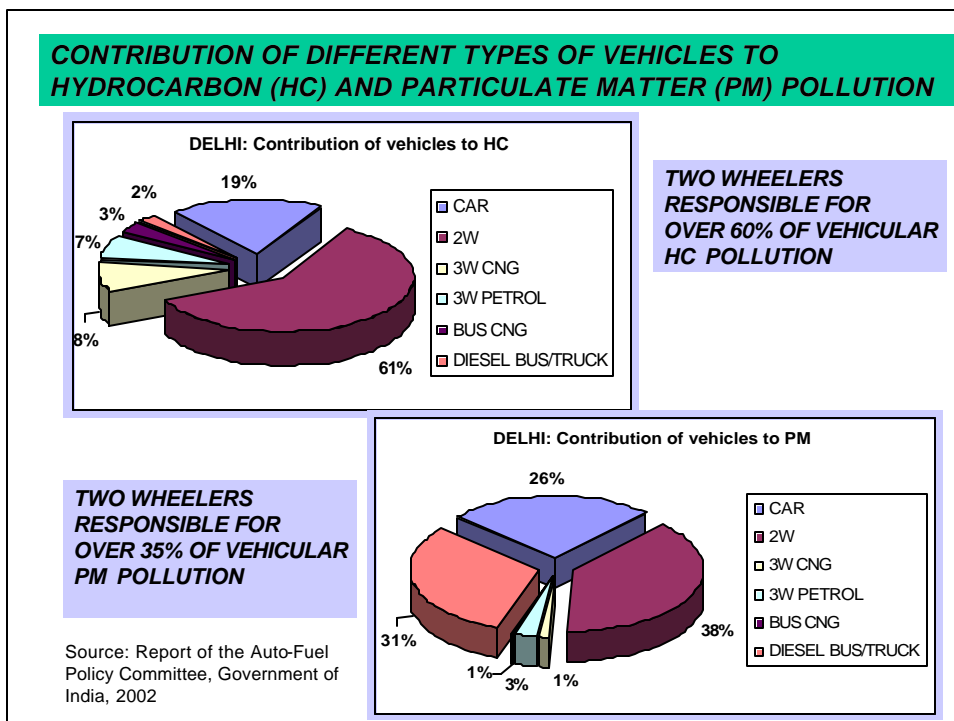
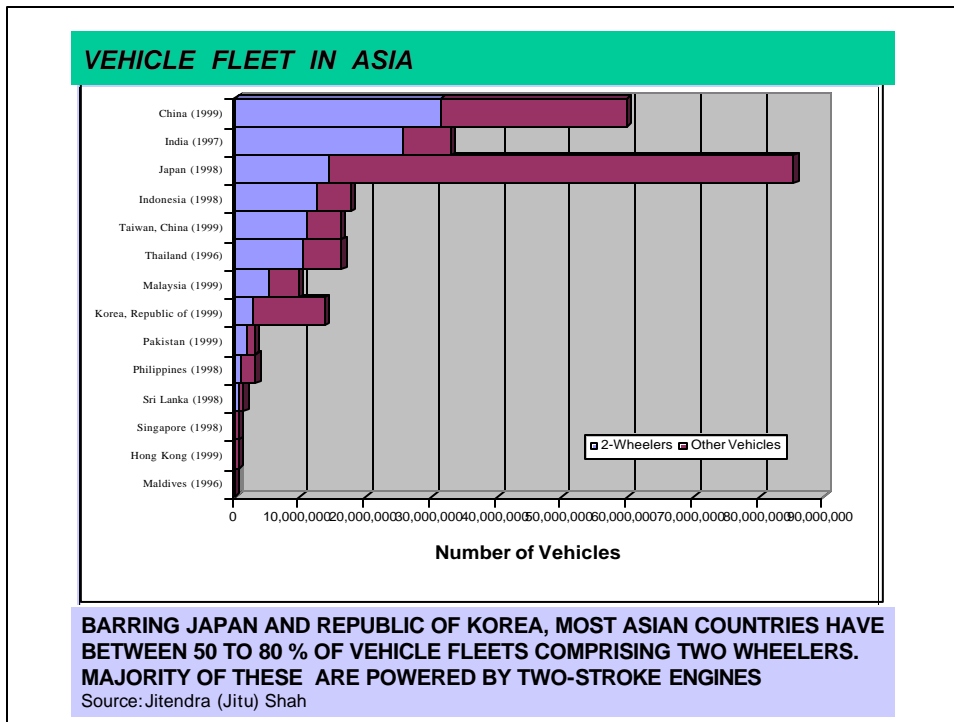
MAJOR PART OF MOBILITY NEEDS OF PEOPLE IN GROWING ASIAN CITIES LIKE DELHI MET BY TWO & THREE WHEELERS - BOTH FOR PERSONAL AND PUBLIC TRANSPORT

Source: Report of Auto-Fuel Policy Committee, Government of India, 2002



TWO WHEELER POPULATION IN A CITY LIKE DELHI HAS NEARLY DOUBLED IN THE LAST DECADE

Source: Motor Transport Statistics, Government of India & SIAM

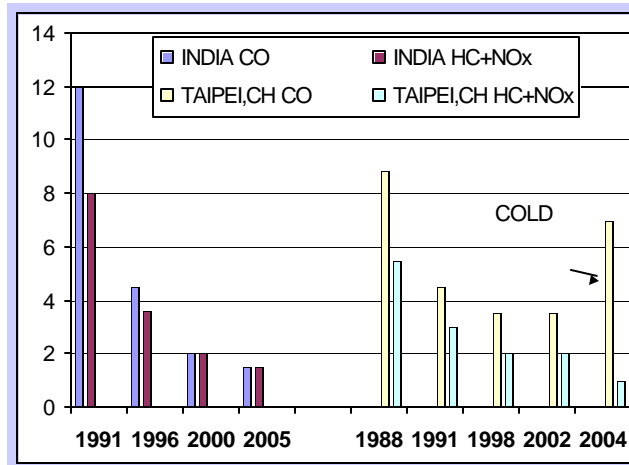


TYPICAL STRATEGIES ADOPTED BY MAJOR ASIAN COUNTRIES TO REDUCE TWO WHEELER POLLUTION

- | | |
|---|---|
| <ul style="list-style-type: none"> • ENFORCEMENT OF PROGRESSIVELY STRINGENT EMISSION STANDARDS FOR NEW VEHICLES • ENFORCEMENT OF EMISSION STANDARDS FOR IN-USE VEHICLES • STRENGTHENING EMISSION INSPECTION & MAINTENANCE • INTRODUCTION OF IMPROVED 2-STROKE LUBRICATING (2-T) OILS • MANDATING/PROMOTING USE OF 'LOW SMOKE' 2-STROKE LUBRICATING OILS • MANDATORY DISPENSING OF 2-T OIL PRE-MIXED WITH PETROL • PROMOTION OF ALTERNATIVE FUELS (CNG/LPG) FOR THREE WHEELERS • COMPLETE PHASE OUT OF LEADED PETROL | <ul style="list-style-type: none"> • TAIPEI, CHINA, INDIA, THAILAND • MANY COUNTRIES • TAIPEI, CHINA • JAPAN, THAILAND, TAIPEI, CHINA, INDIA • INDIA, THAILAND • INDIA • INDIA, THAILAND • MANY COUNTRIES |
|---|---|

MASS EMISSION STANDARDS FOR NEW TWO WHEELERS (g/km)							
COUNTRY	VEHICLES	YEAR	CO	HC	NO _x	HC+NO _x	REMARKS
INDIA	ALL 2W	2000	2			2	IDC
	ALL 2W	2005	1.5			1.5	IDC, DF of 1.2
INDONESIA	ALL 2W	2001	12			10	
		2007	5			3	
NEPAL	ALL 2W	1999	2			2	
PRC, CHINA	MOPEDS	2001	6			3	ECE R 47
	MOPEDS	2005	1			1.2	ECE R 47
	M/CY, 2S	2002	8	4	0.1		ECE R 40
	M/CY, 4S	2002	13	3	0.3		ECE R 40
BEIJING	ALL 2W	2003	4.5			3	ECE R 40
	ALL 2W	2004	3.5			2	ECE R 40
TAIPEI, CHINA	< 700 CC	2002	3.5			2	CNS 11386
	<700cc,2S	2004	7			1	COLD START
	<700cc,4S	2004	7			2	COLD START
THAILAND	ALL 2W	2001	4.5			3	
	<110cc	2003	3.5			2	
	>110cc	2004	3.5			2	
VIET NAM	M/CYCLES	2004	4.5			3	
	M/CYCLES	2007	3.5			2	
	MOPEDS	2004	6			3	
	MOPEDS	2007	1			1.2	

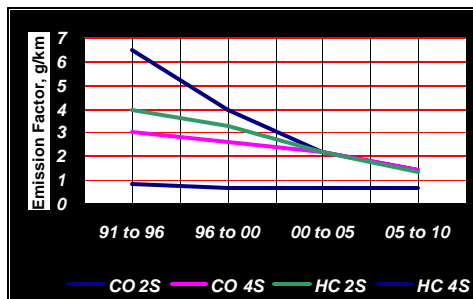
PROGRESSIVE STRINGENCY OF MASS EMISSION STANDARDS FOR NEW MOTORCYCLES IN TAIPEI, CHINA AND INDIA



NOTES: (1) ALL VALUES ARE IN g/km. (2) TAIPEI, CHINA STANDARD FOR CO IS WITH COLD START. (3) FIGURE FOR TAIPEI, CHINA SHOWS 2004 LIMIT FOR 2-STROKE VEHICLES ONLY. FOR 4-STROKES THE LIMIT IS 2 g/km

PROGRESSIVE REDUCTION OF 2-WHEELER EMISSION FACTORS IN INDIA DUE TO STRINGENT EMISSION STANDARDS

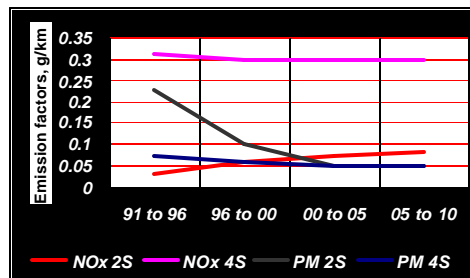
(Source: Transport Fuel Quality for Year 2005, CPCB, Dec 2000)



HIGHEST DECLINE SEEN IN 2-STROKE CO, FOLLOWED BY 2-STROKE HC. 4-STROKE HC REMAINS BY AND LARGE LOW AND STEADY

HIGHEST DECLINE SEEN IN 2-STROKE PM *
AN INCREASE IS SEEN IN 2-STROKE NOx
4-STROKE NOx RELATIVELY HIGH AND STEADY

* PM Emission Factors need to be considered with caution since these are based on limited data



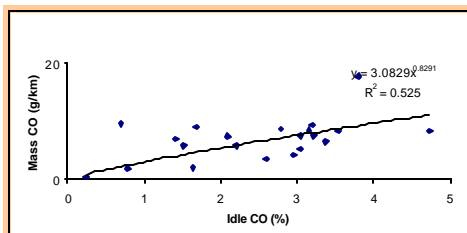
2-WHEELER IN-USE EMISSION STANDARDS IN ASIAN COUNTRIES					
COUNTRY	VEHICLE	YEAR	CO	HC	PM
			% vol	ppm, vol	% opacity
CAMBODIA	ALL 2-W	CURRENT	4.5	10,000	
INDIA	ALL 2-W	CURRENT	4.5		
	2-STROKE	2003	3.5*	9,000	
	4-STROKE	2003	3.5*	6,000 #	
PHILIPPINES	ALL 2-W	CURRENT	6		
PRC, CHINA	ALL 2-W	CURRENT	4.5		
BEIJING	2-STROKE	CURRENT	4.5	8,000	
	2-STROKE	2001	1.5	3,000	
	4-STROKE	CURRENT	4.5	2,200	
	4-STROKE	2001	1.5	300	
SRI LANKA	ALL 2-W	CURRENT	6		
TAIPEI, CHINA	ALL 2-W	CURRENT	4.5	9,000	30
	<700cc	2002	4.5	9,000	30
	2-STROKE	2004	3.5	2,000	30
	4-STROKE	2004	3.5	2,000	30
THAILAND	ALL 2-W	CURRENT	4.5	10,000	30
VIET NAM	2-STROKE	CURRENT	4.5	10,000	
	4-STROKE	CURRENT	4.5	1,500	
*For Post-2000 vehicles # Proposed					

IMPACT OF MINOR MAINTENANCE ON IDLE CO AND HC EMISSIONS - RESULTS OF EMISSION INSPECTION CLINIC HELD BY SIAM IN DELHI

	CO	HC	Fuel Efficiency
	%, vol	ppm, vol	km/litre
Sample, numbers	3,090	3,090	210
Before Maintenance	5.64	5685	48.42
After Maintenance	2.86	2302	58.57
Improvement, %	49	59	21
NOTES			
SAMPLE NUMBERS ARE OF VEHICLES FAILING THE			
CO LIMIT OF 4.5% OUT OF TOTAL 58,000 TESTED			
MAINTENANCE INCLUDED IDLE ADJUSTMENT, AIR			
FILTER CLEANING AND SPARK PLUG CLEANING			
FUEL EFFICIENCY TESTS DONE ON ROAD UNDER			
NEARLY CONSTANT SPEED RUNNING			

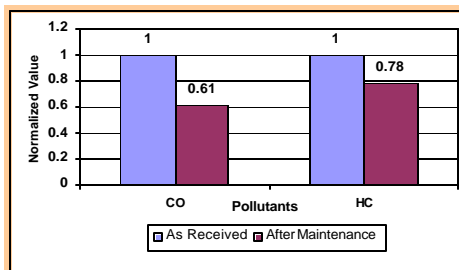
RESULTS SHOW THAT A PROPERLY OPERATED EMISSION INSPECTION SYSTEM CAN BRING ABOUT SIGNIFICANT REDUCTION IN EMISSIONS. THERE IS ALSO AN ATTENDANT FUEL ECONOMY BENEFIT TO USER

IMPACT OF MINOR MAINTENANCE ON MASS EMISSIONS OF IN-USE VEHICLES

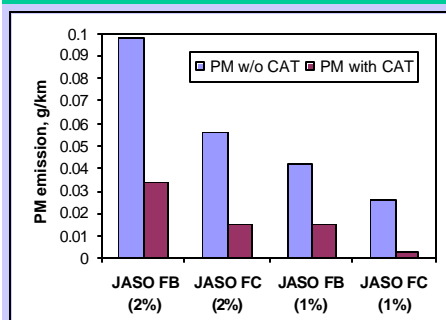


TWENTY TWO VEHICLES OUT OF THE CLINIC WERE TESTED FOR MASS EMISSIONS CORRELATION BETWEEN IDLE & MASS EMISSIONS WEAK

IN SPITE OF THE WEAK CORRELATION A SIGNIFICANT REDUCTION IN MASS EMISSIONS WAS OBSERVED AFTER MINOR MAINTENANCE



POTENTIAL CONTROL MEASURES TO REDUCE PM EMISSIONS FROM NEW AND IN-USE 2-STROKE VEHICLES



LIMITED RESEARCH STUDIES SHOW THAT 2-STROKE PM EMISSIONS ARE MAINLY DERIVED FROM 2-T OIL AND CAN BE CONTROLLED BY REDUCING THE OIL DOSAGE, USE OF SUPERIOR 'LOW SMOKE' OIL AND OXIDATION CATALYTIC CONVERTERS

Further studies are required to reaffirm these findings

Sources: JARI/JAMA, Palke, SAE paper No 1999-01-3299, Sakai, SAE paper No 1999-01-3260

PM EMISSION FACTORS AS A FUNCTION OF AMOUNT & TYPE OF LUBRICANT FOR WELL MAINTAINED 2-STROKE MOTORCYCLES WITHOUT ANY ADVANCED EMISSION CONTROL TECHNOLOGIES.

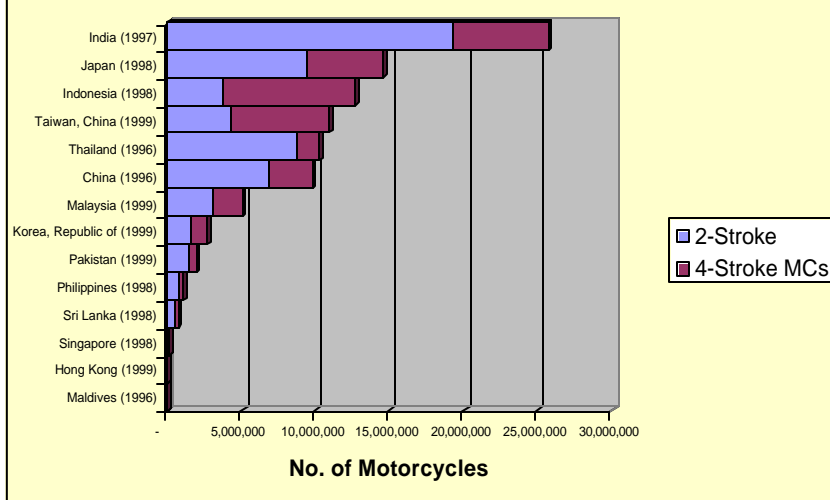
Emission factors are approximations based on limited available data & are indicative of trends

SOURCE: MASAMI KOJIMA et al, THE WORLD BANK, 2000

OIL TYPE & CONTENT	PM g/km	% reduction
Regular 2T, 6-8%	0.6 - 0.7	
Regular 2T, 5%	0.35	50
Regular 2T, 2-3%	0.25	64
Regular 2T, 1 - 2%	0.2	71
Low smoke, 1%	0.15	79

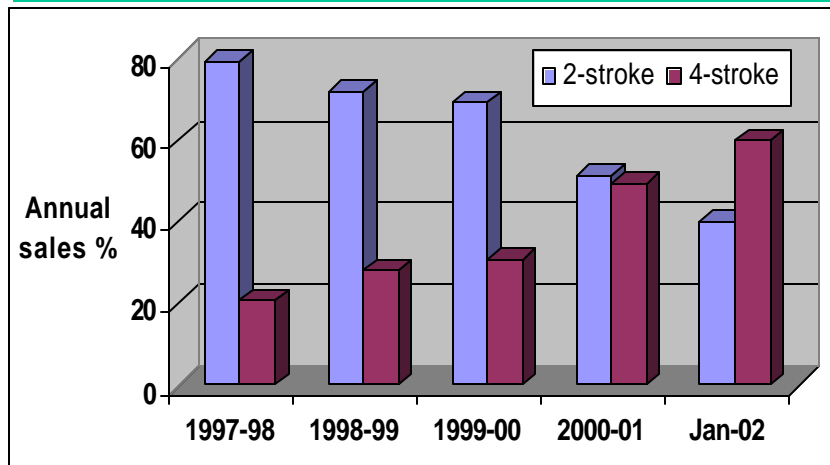
MOTORCYCLE POPULATION IN ASIAN COUNTRIES BY TYPE - PROPORTIONS OF 2-STROKE & 4-STROKE

Source: Jitendra (Jitu) Shah



BARRING INDONESIA & TAIWAN, CHINA, MOST COUNTRIES HAVE HIGH PROPORTIONS OF 2-STROKE MOTORCYCLES

RAPIDLY INCREASING PROPORTIONS OF 4-STROKE MOTORCYCLES IN INDIA IN THE LAST FIVE YEARS



TREND ATTRIBUTED TO STRINGENT EMISSION STANDARDS AND CHANGING CUSTOMER PREFERENCES. PENETRATION OF 4-STROKE MAINLY IN MIDDLE & HIGHER PRICE SEGMENTS. PENETRATION POOR IN LOW COST SEGMENTS SUCH AS MOPEDS, SCOOTERETTES ETC

PROGRESS IN EUROPE & JAPAN

FORTHCOMING NEW MOTORCYCLE			
EMISSION STANDARDS IN EUROPEAN UNION			
	CO	THC	NOx
STAGE 2 (2003)			
<150 cc	5.5	1.2	0.3
>= 150 cc	5.5	1	0.3
TEST CYCLE ECE R40 w/o 40 sec idle			
STAGE 3 (2006)			
<150 cc	2	0.8	0.15
UDC (ECE R40 x 6 cycle sampling) cold start			
>= 150 cc	2	0.3	0.15
TEST CYCLE: UDC cold start + EUDC or WMTC			

OTHER ASPECTS

- Decision by December 2002 on
- * Mandatory CO₂ measurement at approval
- * PM test procedure for 2-stroke and diesel 2-wheelers
- * Durability test procedure
- * In-use counter-measures
- * Necessity of regulations for OBD installation
- * Evaporative emissions

- **PROGRESS IN JAPAN**
- **Hearing by Central Environment Council ON**
- (1) Emission regulation tightening in general
- (2) Emission test procedure (cold start, off-cycle measures, evaporative emissions)
- (3) Durability distance
- (4) Non-regulated matter (PM, HC, PRTR and Greenhouse gases)
- (5) Fuel and lubricant
- The collection of emission factors is underway for accurate **estimation of the amount of greenhouse gas** emissions from mobile sources.
- Experts are studying **methods of estimating the amount of PRTR emissions** and are discussing the initiation of PRTR data disclosure

THE WAY AHEAD FOR ASIAN COUNTRIES

- **Some Asian countries (notably Taipei, China & India) have adopted stringent mass emission standards for new motorcycles that are tighter than in other parts of the world. Other countries need to leapfrog by adopting similar stringent standards. These standards need to be evolved in a transparent manner involving all stakeholders**
- **Countries with serious PM problem need to develop new standards for PM - based on sound science and a reliable measurement system. These countries should also adopt in-use PM standards using reliable test methods**
- **In-use standards ensure proper vehicle maintenance. Tight in-use standards can be used to force older, higher polluting vehicles to be retired or moved away from 'hot-spots'.**
- **Present in-use standards regulate idle CO, HC and Smoke (opacity). There is a need to evolve better test procedures that accurately identify 'gross polluters'.**
- **Lead free petrol is a must for using catalytic converters and low sulphur content necessary to improve durability**
- **Supply of 'Low Smoke' (JASO FC) 2-stroke oil pre-mixed with petrol at filling stations can help to control excessive oil consumption thereby reducing smoke and PM emissions from 2-stroke vehicles**
- **There is a need to institute local studies to characterize 2-3 wheeler PM emissions and reaffirm the relationship between 2-3 wheeler pollutants and health effects.**
- **There is also a need to determine actual 'emission factors' for 2-3 wheeler emissions to build accurate inventories that will guide policy making**