Natural Resource Accounts of Air and Water Pollution: Case Studies of Andhra Pradesh and Himachal Pradesh States of India

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M. N. Murty and S.C. Gulati

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Institute of Economic
Growth
University of Delhi Enclave
North Campus, University of Delhi
Delhi-110007
Phone:+91-11-27667-288/365/424; Fax : +91-11-27667410

Preface

This study is an output of the research project funded by the Central Statistical Organization (CSO), Ministry of Statistics and Programme Implementation, Government of India. The progress of work of this research project has been reported in 5 meetings of Technical Monitoring Committee on Natural Resource Accounting of CSO during last two years. We are grateful to the Chairman and members of this committee for providing us useful comments at various stages of the progress of the work. We express our thanks to Professor Subasish Gangopadhyay for useful comments made on the draft report of this project submitted to CSO earlier.

Part of the work done for this project has already appeared as four working papers of our institute which were presented at our institute's research workshops and two international seminars on `Environment and Sustainable Development' at Gokhale Institute of Politics and Economics, Pune, and Jawharlal Nehru University, New Delhi in April, 2005 and two international conferences: Annual Conference of European Association of Environmental and Resource Economists, Bremen, Germany, 23-26, July, 2005 and the third World Congress of Environmental and Resource Economists, Kyoto, Japan, July 3-7, 2006. Three of the research papers prepared from the work done for this project are accepted for publication in the European Journal, Environmental and Resource Economics and the Indian journals, the Economic and Political Weekly and the Indian Economic Journal.

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M.N. Murty
S.C. Gulati

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2.1 Environmentally Sustainable Income

Measurement of environmentally sustainable income requires a system of national accounts integrating the environmental and economic problems. There are many definitions of sustainable income. The general view about sustainable income is that it is the maximum attainable income in one period with the guarantee that the same level of income will be available in future periods given the constraints on the resources, viz. labor, man made capital and natural capital. Therefore, income is straightaway related to the availability of man made and natural capital. The sustainable income defined in this way represents the welfare of the nation and there is a lot of discussion in the literature about whether the net national product (NNP) would appropriately represent it. Samuelson (1961) has argued, the rigorous search for a meaningful welfare concept leads to a rejection of current income concepts like NNP and end up something closer to a wealth like magnitude such as the present discounted value of future consumption. However, Weitzman (1974) has shown that in theory, the NNP is a proxy for the present discounted value of future consumption[1].

It is long recognized that the conventional system of national accounts (SNA) to measure NNP has treated the environmental resources and their role in the economy inconsistently. Under SNA, NNP increases when natural resource stocks are depleted and the quality of environment is reduced by pollution. As could be seen in Section 2 of this chapter, the correct approach to natural resources accounting is to account for the depletion of natural resources and the fall in the environmental quality in estimating the NNP. There is now a lot of literature about the problem of estimating NNP and the sustainable use of natural resources. Studies by Solow (1974) and Hartwick, (1977, 1978a,b) have tried to derive the conditions under which real consumption expenditure might be maintained despite declining stocks of exhaustible resources (fossil fuels, minerals and metals). The main result of these studies known as the Hartwick rule, states that consumption may be held constant in the face of exhaustible resources only if the

[1] See for details Murty and Surender Kumar (2004).

rents deriving from the inter-temporally efficient use of those resources are reinvested in the reproducible capital. The relationship of the Hartwick rule with sustainable income hinges on the assumption of the substitutability between manmade capital and natural capital. Solow (1974) has shown that in the case of manmade capital (which could be also natural capital) the optimal inter-temporal resource allocation requires the maintenance of existing capital stock by making the investment exactly equal to depreciation.

The main criticism about the Solow-Hartwick definition of sustainable income is that the man made capital could not be substituted to natural capital. Natural capital can be exploited by man, but cannot be created by man. According to the thermodynamic school (Christensen, 1989), natural capital and man made capital are not substitutable. One can think of two subsets of inputs, one containing the natural capital stock `primary inputs' and another containing man made capital and labor `agents of transformation'. The substitution possibilities with in each group can be high while they are limited between the groups. Increasing income means increasing the use of inputs from both groups. Given the limited substitutability between man made capital and natural capital, it is necessary to maintain some amount of the natural capital stock constant in order to maintain the real income constant at the current level over time (Pearce et al., 1990; Klaasen and Opschoor, 1991; Pearce and Turner, 1990). This can be a heavy restriction on development if the current levels of natural capital stocks are chosen as a constraint, since it requires a banning of all projects and policies impacting the natural capital stock. As a way out of this problem, Pearce et al. suggest the use of shadow projects. These are the projects and policies designed to produce environmental benefits in terms of additions to natural capital to exactly offset the reduction in natural capital resulting from the developmental projects and policies. Daly (1990) has suggested some operational principles for maintaining natural capital at a sustainable level. For example (1) in the case of renewable resources, set all harvest levels at less than or equal to the population growth rate for some predetermined population size, (2) for pollution, establish assimilative capacities for receiving ecosystems and maintain waste discharges below these levels, and (3) for non-renewable resources, receipts from non-renewable extraction should be divided into an income stream and an investment stream. The investment stream should be invested in renewable substitutes (biomass for oil).

2.2 Shadow Prices of Environmental Resources and Net National Product

Conventional NNP could be measured as consumption plus the value of net addition to manmade capital (net investment). If environmental resources (air, water, and forests) are considered as natural capital, net investment includes the value of decline in natural capital goods. Shadow prices of natural capital have to be obtained for valuing the changes in natural capital stocks for defining a correct measure of NNP. A correct measure of NNP as shown below incorporates the current loss in value of natural resource stocks due to use of environmental resources[2]. The accounting prescription for measuring NNP taking the renewable (environmental) resources as natural capital is described below.

Consider an economy producing a commodity X_t using capital stock K_t, and labour L_t, The production function of X_t is given by:

$$X_t = F(K_t, L_t). \qquad (2.1)$$

F is concave and an increasing and continuously differentiable function of each of its variables. Let C_t represent aggregate consumption at time t, and E_t and M_t represent respectively emissions and the pollution abatement expenditure in the production of X at time t. The net accumulation of physical capital therefore satisfies the condition

$$dK / dt = F(K_t, L_t,) - C_t - M_t \qquad (2.2)$$

Let S_t represent the stock of environmental resources (quality of water resources or atmosphere) at time t, N (S_t) the natural rate of regeneration of this stock (natural rate of assimilation of pollution loads), and E_t, the rate of depletion of stock (rate of degradation of environmental quality). Therefore, the net accumulation of the stock of environmental resources satisfies the condition

$$dS_t / dt = N(S_t) - E_t + A_t \qquad (2.3)$$

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[2] For the details see Hartwick (1990); Maler (1991), Dasgupta and Maler(1998) and Murty and Surender Kumar (2004)

where A_t is the rate of pollution abatement. The pollution abatement cost function is given as $M_t = M(A_t)$

Assuming that the utility depends on the change in stock of the environmental resource, the inner-temporal utility function in the utilitarian form is given as:

$$\int_0^\infty U(C_t, L_t, \dot{S}) e^{-rt} dt \qquad (2.4)$$

where U is strictly concave, increases in C, S, and decreases in L and r is the rate of discount. Consider the planning problem of government consisting of variables, C, L, A, K, and S. Given the initial stocks of man made capital and natural capital, K_0 ans S_0, the planning problem is feasible if it satisfies conditions (2.1) to (2.3).

The planning problem is

$$\text{Maximize} \int_0^\infty U(C_t, L_t, \dot{S}_t) e^{-rt} dt \qquad (2.5)$$

subject to the constraints (2.2) and (2.3).

The control variables of this optimization problem are C_t, L_t, and A_t while the state variables are K_t , and S_t.

The Hamiltonian of this maximization problem is

$$H(t) = U(C_t, L_t, \dot{S}_t) + p_t \{F(K_t, L_t) - C_t - M_t\} + q_t\{N(S_t) - E_t + A_t\} \quad (2.6)$$

where p(t), and q(t) are co-state variables. The canonical equations for this optimization problem are

$$U_C = p_t \qquad (2.7a)$$

$$-U_L = p_t F_L = w \qquad (2.7b)$$

$$-U_S + p_t \, dM / dA = q_t \qquad (2.7c)$$

$$F(K_t, L_t) - C_t - M_t = 0 \qquad (2.7d)$$

$$N(S_t) - E_t + A_t = 0 \qquad (2.7e)$$

$$dp / dt = - dH / dK_t \qquad (2.7f)$$

$$dq / dt = - dH / dS_t \qquad (2.7g)$$

Transversality conditions

$$\lim_{t \to \infty} p_t = 0 \qquad (2.7h)$$

$$\text{Lim } q_t = 0 \qquad (2.7i)$$

$t \rightarrow \infty$

From (2.7c) we have

$$dM / dA = (U_S + q_t)/ p_t \tag{2.8}$$

Equation (2.7a) implies that along the optimal path the price of consumption is equal to its marginal utility, and equation (2.7b) implies that wage rate is equal to marginal disutility of labor. Equation (2.7c) shows that the industry carries pollution abatement up to the level at which the net marginal cost (marginal cost minus marginal utility from the reduced pollution) is equal to the price it has to pay for the waste disposal services. Equation (2.8) shows that the marginal cost of abatement of pollution is equal to its shadow price. In case, S does not enter the utility function, the shadow price is simply q_t. Using Euler's theorem, it could be written that

$$U(C_t, L_t, \dot{S}_t) = U_c C_t + U_L L_t + U_S \dot{S}_t \tag{2.9}$$

Therefore, equation (2.6) could be written as

$$H_t = U_c C + U_L L + U_S \dot{S} + p \dot{K} + q \dot{S} \tag{2.10}$$

Taking consumption as numeraire and using equation (2.8), equation (2.10) could be written as

$$H_t = C + \dot{K} + U_L L / p_t + M^{/}. \dot{S} \tag{2.11}$$

The first three components on the right hand side of equation (2.11) constitute the conventional national income. The fourth component is the product of change in the environmental resource stock (pollution) and the marginal cost of pollution abatement. That means, the marginal cost of pollution abatement is the shadow price of pollution. If dS / dt is less than zero meaning that the environmental quality falls with the economic development, equation (2.11) shows that the pollution abatement cost has to be deducted from the NNP to get environmentally corrected NNP (ENNP). Alternatively, the shadow price of pollution could be interpreted as the marginal welfare gain from the pollution reduction as given in the right hand side of equation (2.8).

2.3 Use of Exhaustible Resource as a Source of Pollution: The CO_2 Problem

The above model provides an accounting principle for measuring ENNP when a renewable environmental resource is used. There could be cases in which use of an exhaustible resource results in the use of renewable environmental resource. The CO_2 problem is one of such cases. Use of fossil fuels for the production and consumption results in the depletion of exhaustible resources and the pollution of environment from the burning fuels. Assume that an exhaustible resource such as coal or oil, say Y_t is used in the production of X_t apart from capital and labor and the pollution load E_t is proportional to the resource Y_t used. That means $E_t = a Y_t$ where a is the ratio of pollution load to the amount of resource used.

The production function of X_t is given by:

$$X_t = F(K_t, L_t, Y_t). \quad (2.12)$$

F is concave and an increasing and continuously differentiable function of each of its variables. Let C_t represent aggregate consumption at time t, and E_t and M_t represent respectively emissions and the pollution abatement expenditure in the production of X at time t. The net accumulation of physical capital therefore satisfies the condition

$$dK / dt = F(K_t, L_t,) - C_t - M_t - vY_t \quad (2.13)$$

where v is the price per ton of coal.

Let R_t represent the stock of exhaustible resource say coal. The rate of depletion of this stock, if fresh discoveries of the resource are not there, is given by

$$dR / dt = - Y_t \quad (2.14)$$

Let S_t represent the stock of environmental resources (quality of water resources or atmosphere) at time t, and N (S_t) the natural rate of regeneration of this stock (natural rate of assimilation of pollution loads). Therefore, the net accumulation of the stock of environmental resources satisfies the condition

$$dS_t / dt = N(S_t) - a Y_t + A_t \quad (2.15)$$

where A_t is the rate of pollution abatement. The pollution abatement cost function is given as $M_t = M(A_t)$.

Assuming that the utility depends on the change in stock of the environmental resource, the inter-temporal utility function in the utilitarian form is given again as in equation (2.5).

The Hamiltonian of this maximization problem is

$$H(t) = U(C_t, L_t, \dot{S}_t) + p_t \{F(K_t, L_t, Y_t) - C_t - M_t - vY_t\} + q_t\{N(S_t) - a Y_t + A_t\} + r_t(-Y_t) \quad (2.16)$$

where p(t), q(t), and r_t are co-state variables. The canonical equations for this optimization problem are

$$U_C = p_t \quad (2.17a)$$

$$-U_L = p_t F_L = w \quad (2.17b)$$

$$-aU_{\dot{S}} + p_t (F_y - v_t) - aq_t = r_t \quad (2.17c)$$

$$-U_S + p_t M^{/} = q_t \quad (2.17d)$$

From (17d) we have

$$M^{/} = (U_S + q_t)/ p_t \quad (2.18)$$

and from (2.17c) and (2.17d) we have

$$r_t = ((F_y - v_t) - aM^{/})) p_t \quad (2.19)$$

By the linear approximation of the utility function U, the Hamiltonian in (2.16) could be written as

$$H_t = U_C C_t + U_L L_t + U_S \dot{S}_t + p_t \dot{K}_t + q_t \dot{S}_t + r_t \dot{R}_t \quad (2.20)$$

Taking consumption as numeraire and using equations (2.18) and (2.19), (2.20) could be written as

$$H_t = C_t + U_L L_t / p_t + \dot{K}_t + M^{/} \dot{S} + \{((F_y - v_t) - aM^{/})\} \dot{R}_t \quad (2.21)$$

The first four components are the same as those in equation (2.11). The term $\{((F_y - v_t) - aM^{/})\}$ in the equation could be interpreted as the generalized Hotelling rent on the fossil fuels after accounting for the cost of abatement of pollution arising out of use of the resource. By using say one ton of fossil fuel, a tons of pollution is generated and the cost of abatement of it is a $M^{/}$, which has to be accounted in defining the Hotelling rent. It is so because the cost of depletion of environmental quality due to pollution evaluated at the shadow price, the marginal cost of pollution abatement, is already accounted in measuring ENNP through the forth component in equation (2.21).

2.4. System of Integrated Economic and Environmental Accounting (SEEA)

The theoretical model for the environmental and economic accounting described in Section 2.2 shows that for the estimation of ENNP, changes in the stocks of environmental resources have to measured and valued at their shadow prices. That means we have to develop physical and monetary accounts of natural capital to measure ENNP as

$$ENNP = C + P_K \Delta K + P_N \Delta N$$

where,

C: Consumption

ΔK: Change in manmade capital stock

ΔN: Change in natural capital stock

P_K: Shadow price of man made capital

P_N: Shadow price of natural capital

There are two important aspects in the development of integrated economic and environmental accounting. First the description of environment in physical terms by defining an asset boundary that is more extensive than that is given in the conventional national accounts. A distinction has to be made between natural and manmade assets. Natural assets consists of biological assets, land and water areas with their ecosystems, subsoil assets and air. The second is the valuation of natural assets. Natural assets provide both marketable and non-marketable services and therefore their valuation requires the use of market and non-market valuation techniques.

The UN methodology[3] of integrated environmental and economic accounting describes environmental accounting as a satellite system of a core system of conventional national accounts. The development of environmental accounts as a satellite system of core accounts of SNA starts with the review of those parts of the conventional SNA that form the conceptual basis for the development of SEEA. The relevant parts of SNA are the supply and use table of produced goods and services, and the non-financial asset accounts

[3] UN (1993b)

that include the opening and the closing balance sheets of produced and non-produced natural assets as well as the changes therein as a result of capital formation and other changes in the assets. The supply and use tables show the supply of domestic and imported goods and services, their use for intermediate or final demand, and the value added connected with production in economic activities. The non-financial asset accounts comprise opening stocks at the beginning of the accounting period, price and volume changes during the period and the closing stocks at the end of the period.

The SNA already has some information related to the environment. Part of this information is explicitly identified in various categories of its classification, notably those of asset accounts. Further environmental related information can be obtained by disaggregation of SNA classifications without modifying the basic accounting structure. Environmental protection services are identified within intermediate consumption of industries, final consumption by government and households and investment. The separate identification of environmental protection expenses gives a comprehensive picture of the efforts made by the different sectors and institutions in the economy to protect environment. Using the input-output analysis one could assess the direct and indirect value added contributions to gross national product by the environmental protecting activities. Such accounting also helps one to know how capital-output ratios are affected by investment in environmental protection equipment. First of all, non-financial asset accounts are divided into produced assets of industries and non-produced natural assets. The produced assets are divided into manmade assets and natural assets. In the case of man-made assets, they are further subdivided into assets created for external environmental protection services and internal environmental protection.

The development of SEEA by showing environmental accounts as satellite accounts starts with the description of two proto types of environmental accounting in physical terms: material energy balances and natural resource accounting. Material and energy balance accounting shows raw materials as inputs, transformation process in the economy, and flows of residuals resulting from the economic uses of materials back to the environment. Transformation processes within the natural environment are excluded. Natural resource accounting describes the stocks and stock changes of natural assets, comprising biological assets (produced or wild), subsoil assets (proved reserves), water, air and land areas with their terrestrial and aquatic ecosystems. Biological natural assets consist of plants and animals of economic importance. Land areas include area as well as related biological ecosystems. Subsoil assets consist only of proved reserves. Water and air are accounted in so far as they are used or affected by the economic activities.

In SEEA the environmental accounts are developed as satellite accounts of SNA by combining the concepts of material/ energy and natural resource accounting. The physical accounts of the SEEA extend the SNA without modifying the monetary flow and asset accounts of the SNA. Monetary data in SNA are described in terms of their counterparts in physical terms. Physical data in the SEEA describe the parts that are not part of the conventional SNA. Linkage of the physical data with monetary accounts is obtained by bridging matrices that applied compatible concepts at the interface between SEEA and SNA.

2.5 Valuation in SEEA

The methods of valuation of environmental services could be classified as three different valuation types: (a) market valuation according to the concept of the non-financial asset accounts in the conventional system of national accounts, (b) maintenance valuation, which estimates the cost necessary to sustain at least the present level of natural assets, and (c) on market valuation using hypothetical behavioral methods: contingent valuation methods and the observed behavioral methods: hedonic prices, travel cost and household production functions for estimating the value of consumptive services of natural environment.

The maintenance valuation method uses actual or hypothetical cost data. Expenditures required for maintaining the services of natural environment constitute the actual cost. These are the costs for the mitigation of damage caused by the decreased environmental quality or for an increase in environmental protection activities that prevent degradation of natural assets. These could be interpreted as the value producer or polluter places on environmental services he receives or the demand price of producer for the environmental services. The hypothetical cost of using environment is the cost that would have been incurred if the environment had been used in such a way that would not affect its future use. The rationale behind using this method of valuation is the concept of sustainable income discussed in the earlier sections. The maintenance cost method of valuation is used in this study to develop the source specific physical and monetary accounts of air and water pollution for different sectors/industries in AP and HP states (chapters III, V, and VI).

The producer value of environment described above will not capture the entire value of decrease in environmental quality and they can be interpreted as the minimum value of a change in the environmental quality. The estimates of damages to households from the environmental pollution made using the direct valuation methods may be higher than the producer values. There is a lot of literature now about the use of behavioral methods for estimating the household values of environmental resources (Freeman, 1993; Mitchell and Carson, 1989; Murty and Surender Kumar (2004)). The hypothetical behavioral methods comprising contingent valuation and other variants of this can be used to measure both user and non-user benefits from environmental resources. The observed behavioral methods indirectly use market information to estimate user benefits. There are a number of empirical studies made in India using the methods of contingent valuation, hedonic prices, household health production function and travel cost for estimating the consumptive benefits from improved air and water quality and reforestation. In the case of air and water pollution, some of these studies provide estimates of individual marginal willingness to pay for improved ambient air quality in an urban area or the improved ambient water quality of a river (Murty, Gulati and Banerjee 2004; Markandya and Murty, 2000). The observed behavioral method of hedonic prices is used in this study for developing monetary accounts of ambient air pollution for some urban areas in the states of AP and HP (Chapter IV).

The shadow price of an environmental resource is defined as the value of unit depletion of the resource measured in terms of foregone net national product as shown in Section 2. Dasgupta and Maler (1998) have shown that the same definition of shadow price of a natural resource could be carried to the second best situations in the economy, especially for valuing small perturbations in natural resource stocks caused by an investment project. There are two views about the shadow prices according to the two approaches of valuation described above. One view as already mentioned earlier, the shadow price of an environmental resource could be defined as the cost to the producer to avoid a unit depletion of an environmental resource. Therefore in this case, the shadow price could be defined as the marginal cost of air or water pollution abatement or compensatory reforestation. This definition of shadow price is based on the idea of cost of environmentally sustainable development. Another view is that it represents the environmental values of households: user and non-user values and option values which are the consumptive benefits from a unit of resource, say an acre of forest land, a unit improvement in atmospheric or river water quality. Since the environment is a public good, as for example, the atmospheric quality in an urban area, the shadow price of air quality is the sum of consumptive benefits to all residents of that area from one unit improvement in the air quality. In the first best situation in the economy, the two methods of measuring the shadow price of an environmental resource will provide the same estimate because in this case the marginal willingness to pay for the environmental service has to be equal to marginal cost of avoiding the environmental degradation. In a realistic situation in the economy, which is normally the second best, estimates based on the two methods could differ. One could as well arrive at a result in which the marginal willingness to pay is higher than the marginal cost of avoiding degradation. It is important to note that the marginal cost of pollution abatement could be estimated using the data observed in the market as discussed in Chapter III. In contrast, the marginal willingness to pay for an environmental service is not directly observable in the market and it is very difficult to obtain a precise estimate of it as could be seen in Chapter IV.

Incorporation of environmental effects of developing activities in the measurement of Green GDP requires the identification of the effects of these activities on the environmental resource stocks. Take for example an investment project. The project may be contributing to the depletion of environmental resources by generating air and water pollution loads and causing deforestation, as it is the case with a thermal power plant or with a paper and pulp mill. The depletion is measured as an annual flow of pollution (in tonnes) generated and forest degraded (in acres) by the project and the social cost of this depletion is measured at the appropriate shadow prices. This estimated social cost becomes a part of the annual flows of benefits and costs of the investment project in the standard social benefit cost analysis and gets reflected in the measurement of Green GDP. The annual flows of pollution at the project level are given in terms of tonnes of particulate matter, carbon dioxide etc. for air pollution and tonnes of biological oxygen demand, suspended solids etc. for water pollution. For finding out the value urban residents place on a tonne of emissions of particulate matter or the value river users place on a tonne of emissions of biological oxygen demand by the project, one has to study the relation between the pollution at source and the ambient environmental quality. These relationships could be found by modeling urban air quality or river quality. For example, by modeling urban air quality, one could find the effect of one tonne reduction of particulate matter by an investment project on the ambient air quality measured in micrograms of particulate matter in a cubic space (μ gms/m^3). Suppose it results in 1000^{th} of a microgram reduction in ambient air pollution, one could find the value placed on this reduction by a representative individual using the estimated marginal willingness to pay function for air quality improvement. The extrapolation of this value for all the urban residents could provide an estimate of shadow price of a tonne of particulate matter.

2.6 Conclusion

Sustainable income could be defined as the maximum attainable income in one period with the guarantee that the same level of income will be available in future periods given the constraints on the resources: labor, manmade capital and natural capital. The value of depleted natural capital due to economic development has to be taken into account in measuring the sustainable income defined above. The accounting principle for measuring the ENNP is to deduct the value of depleted environmental resources from the NNP estimated using conventional national income accounting. The shadow price of natural environment (air and water quality) could be either the marginal cost of pollution abatement for the polluter or the marginal welfare gain from the pollution reduction.

The measurement of environmentally sustainable income requires the extension of conventional SNA to include the effects of economic activities on the environment and the effects of environment on the economic activities. SEEA suggests satellite accounts to SNA dealing with the environment and economic problems. The development of SEEA starts with the review of those parts of SNA that form the conceptual basis. The SNA already has some information related to the environment, notably in the asset accounts. More environmental related information could be obtained by disaggregating SNA classification without modifying the basic accounting structure. The SEEA provides the monetary data of SNA with the physical data on economic environmental relationships.

The following chapters in this study provide certain approaches and their empirical application for developing physical and monetary accounts of environmental resources. Case studies providing source specific accounts were done for some important air and water polluting sectors: industry, power generation, transport, and agriculture in the states of AP and HP in India. Detailed case studies providing ambient air and water pollution accounts were also done for some important sectors. In preparing the source specific monetary accounts of pollution, the valuation method of maintenance cost is used. The hedonic prices method is used in preparing the monetary accounts of urban ambient air quality in the study areas.

III. Accounting for Cost of Environmentally Sustainable Industrial Development: A Case Study of Thermal Power Generation

3.1 Introduction

Natural environment provides waste disposal services as productive inputs to industry. Given the environmental regulation producers place a value on these inputs similar to the way they value other conventional inputs such as labor, man made capital and materials. Environmental regulation meant for ensuring an environmentally sustainable industrial development imposes a cost on the industry. The UN methodology for an integrated environmental and economic accounting calls this cost as maintenance cost or the cost to the industry for maintaining the quality of environment at its natural regenerative level. A model in the theory of production is considered in this chapter for estimating the maintenance cost. The model describes the technology of power generation as one of producing jointly good output, power and bad output, pollution load, using the output distance function. The producer demand prices for waste disposal services from the environmental media could be defined as the opportunity costs in terms of good output foregone to reduce bad output in this model. In any attempt to measure Green GDP, estimates of these prices are needed to value changes in environmental quality brought out by the developmental activities.

The remaining chapter is organized as follows: the second section discusses the model and its estimation. The third section presents physical and monetary accounts of air pollution in thermal power sector of AP and a method of accounting for air pollution in the estimation of Green GDP. The fourth section provides conclusion.

3.2 A Model Describing Production Processes of Firms with Joint Production of Good Output and Pollution

Suppose that a firm employs a vector of inputs $x \in \Re^N_+$ to produce a vector of outputs $y \in \Re^M_+$, $\Re^N_+$, $\Re^M_+$, are non-negative N-and M-dimensional Euclidean spaces, respectively. Let P (x) be the feasible output set for the given input vector *x* and L (*y*) is the input requirement set for a given output vector *y*. Now the technology set is defined as

$$T = \{(y, x) \in \Re^{M+N}_{+}\ y \in P(x)\}. \quad (3.1)$$

The output distance function is defined as,

$$D_O(y,x) = \min\{\lambda > 0:(y/\lambda) \in P(x)\}\ \forall x \in \Re^{N}_{+}. \quad (3.2)$$

Equation (3.2) characterizes the output possibility set by the maximum equi-proportional expansion of all outputs consistent with the technology set (3.1).

The assumptions about the disposability of outputs become very important in the context of a firm producing both good and bad outputs. The normal assumption of strong or free disposability about the technology implies,

$$\text{if } (y_1, y_2) \in P(x) \text{ and } 0 \le y_1^* \le y_1,\ 0 \le y_2^* \le y_2 \Rightarrow (y_1^*, y_2^*) \in P(x).$$

That means, we can reduce some outputs given the other outputs or without reducing them. This assumption may exclude important production processes, such as undesirable outputs like pollution. The assumption of weak disposability is relevant to describe such production processes. The assumption of weak disposability implies,

$$\text{if } y \in P(x) \text{ and } 0 \le \lambda \le 1 \Rightarrow \lambda y \in P(x).$$

That means, a firm can reduce the bad output only by decreasing simultaneously the output of desirable produce.

The idea of deriving shadow prices using output and input distance functions and the duality results is originally from Shephard (1970). A study by Fare, Grosskopf and Nelson (1990) is the first in computing shadow prices using the distance function and non-parametric linear programming methods. Fare et al.(1993) presents the first study deriving the shadow prices of undesirable outputs using the output distance function.

The derivation of absolute shadow prices for bad outputs using the distance function requires the assumption that one observed output price is the shadow price. Let y_1 denote the good output and assume that the observed good output price (r_1^0) equals its absolute shadow price (r_1^s) (i.e., for m=1, r_1^0=r_1^s). Fare et al. (1993) have shown that the absolute shadow prices for each observation of undesirable output (m=2...M) can be derived as[1],

[1] See Fare (1988) for derivation.

$$(r_m^s) = (r_1^0) \bullet \frac{\partial D_0(x,y) / \partial y_m}{\partial D_0(x,y) / \partial y_1}. \quad (3.3)$$

The shadow prices reflect the trade off between desirable and undesirable outputs at the actual mix of outputs, which may or may not be consistent with the maximum allowable under regulation (Fare et al. 1993: 376). Further, the shadow prices do not require the plants to operate on the production frontier.

3.3 Estimation Procedure and Data:

In order to estimate the shadow prices of pollutants (bad outputs) for thermal power generation in Andhra Pradesh using equation (3.3), the parameters of the output distance function have to be estimated. The trans log functional form[2] used for estimating these functions is given as follows:

$$\ln D_o(x, y) = \alpha_0 + \sum\beta_n \ln x_n + \sum \alpha_m \ln y_m + 1/2\sum \sum \beta_{nn'} (\ln x_n)(\ln x_{n'}) + 1/2 \sum \sum \alpha_{mm'} (\ln y_m)(y_{m'}) + \sum\sum\gamma_{nm}(\ln x_n)(\ln y_m) + \iota_1 d_1 + \iota_2 d_2 + \iota_3 d_3 + \iota_d 4 \quad (3.4)$$

where x and y are respectively, Nx1 and Mx1 vectors of inputs and outputs. There are three inputs: capital, labour, and energy and three outputs: good output, electricity, and bad outputs, SPM, NO_x, and SO_2, and d_i is the dummy variable representing the plant. A linear programming technique is used to estimate the parameters of a deterministic trans log output distance function (Aigner and Chu 1968). This is accomplished by solving the problem,

$$\text{Max} \sum [\ln D_o(x, y) - \ln 1], \quad (3.5)$$

subject to:

(i) $\ln Do(x, y) \leq 0$,

(ii) $(\partial \ln D_o(x, y))/(\partial \ln y_1) \geq 0$,

(iii) $(\partial \ln D_o(x, y))/(\partial \ln y_i) \leq 0$,

(iv) $(\partial \ln D_o(x, y))/(\partial \ln x_i) \leq 0$;

(v) $\sum \alpha_m = 1$

[2] Many earlier studies for estimating shadow prices of pollutants have used the trnaslog functional form for estimating the output distance function. These include Pitman (1983), Fare et al. (1990), and Coggins and Swinton (1996).

$\sum \alpha_{mm} = \sum \gamma_{nm} = 0,$

(vi) $\alpha_{mm} = \alpha_{mm}$

$\beta_{nn} = \beta_{nn}$.

Here the first output is desirable and the rest of (M-1) outputs are undesirable. The objective function minimizes the sum of the deviations of individual observations from the frontier of technology. Since the distance function takes a value of less than or equal to one, the natural logarithm of the distance function is less than or equal to zero, and the deviation from the frontier is less than or equal to zero. Hence the maximization of the objective function is done implying the minimization of sum of deviations of individual observations from the frontier of technology. The constraints in (i) restrict the individual observations to be on or below the frontier of the technology. The constraints in (ii) ensure that the desirable output has a non-negative shadow price. The constraints in (iv) restrict that the shadow prices of bad outputs are non-positive, i.e. weak disposability of bad outputs whereas the restrictions in (v) is the derivative property of output distance function with respect to inputs i.e. the derivatives of output distance function with respect to inputs is non-increasing. The constraints in (v) impose homogeneity of degree 1 in outputs (which also ensures that technology satisfies weak disposability of outputs). Finally, constraints in (vi) impose symmetry. There is no constraint imposed to ensure non-negative values to the shadow prices of undesirable outputs.

Table 3.1:Descriptive Statistics of Variables Used in the Estimation of Distance Function

Variable	Unit	Mean	Standard Dev.	Maximum	Minimum
Electricity	Million Units	298.28	13.91	933.58	0.01
SPM	TT	0.653	0.033	3.526	0.018
SO_2	TT	0.874	0.049	4.268	0.004
NO_{xC}	TT	0.139	0.013	1.984	0.001
Coal	TT	223.46	9.93	667.05	0.01
Capital	Rupees millions	1913.231	905.46	62395.28	148.59
Wage Bill	Rupees millions	255.628	111.03	9332.04	344.16

Note: TT – Thousand Tonnes

The output distance function described above is estimated by considering electricity as a good output and pollution loads of SPM, NO_x, and SO_2 as bad outputs using data about thermal power generation by APGENCO in Andhra Pradesh. Table 3.1 provides the descriptive statistic of variables used in the estimation of the distance function. The estimates of the parameters of the distance function are reported in Table 3.2. Using the estimated distance function, the shadow price of a pollutant is estimated in terms of units of good output foregone for one unit reduction in pollution. The computed shadow prices for a representative plant of APGENCO are Rupees 1043.688, 11539.15, and 5866.812 thousand units of electricity respectively per ton reduction of SPM, NO_x, and SO_2. The current electricity tariff for industries in AP is on the average Rs. 3.60 per unit. Using this price shadow prices of pollutants could be expressed in rupees as reported in Table 3.3.

Table 3.2: Estimates of Parameters of Output Distance Function

Coefficients of the Output Distance Function Model						
Variables	**Description**	**Coefficients**	**Variables**	**Coefficients**	**Variables**	**Coefficients**
Y1	**Electricity**	3.025	**x33**	-0.431	**y3x1**	0.167
Y2	**SPM**	1.297	**y12**	0.032	**y3x2**	-0.268
Y3	**SO2**	1.330	**y13**	0.004	**y3x3**	-0.100
Y4	**NOx**	0.605	**y14**	0.163	**y4x1**	-0.085
X1	**Capital**	-1.041	**y1x1**	-1.095	**y4x2**	0.669
X2	**Wage**	19.104	**y1x2**	0.820	**y4x3**	-0.290
X3	**Coal**	-0.408	**y1x3**	0.213	**x12**	-1.858
Y11		-0.199	**y23**	0.069	**x13**	1.116
Y22		-0.062	**y24**	-0.038	**x23**	0.402
Y33		0.110	**y2x1**	0.199	**Intercept**	
Y44		0.059	**y2x2**	-0.448		
X11		1.692	**y2x3**	0.051		
X22		7.411	**y34**	-0.183		

Description of Variables in the Estimated Distance Function

Names of Variables and their Identification					
Output	Y1	$Coal^2$	x33	SO_2Capita	y3x1
SPM	Y2	OutSPM	y12	SO_2Wage	y3x2
SO_2	Y3	OutSO_2	y13	SO_2Coal	y3x3
NO_x	Y4	OutNO_x	y14	WageCoal	x23
Capital	X1	OutCapital	y1x1	NO_xCapital	y4x1
Wage	X2	OutWage	y1x2	NO_xWage	y4x2
Coal	X3	Outcoal	y1x3	NO_xCoal	y4x3
$Output^2$	y11	SPMSO_2	y23	CapitalWage	x12
SPM^2	y22	SPMNO_x	y24	CapitalCoal	x13
$SO_2{}^2$	y33	SPMCapital	y2x1		
$NO_x{}^2$	y44	SPMWage	y2x2		
$Capital^2$	x11	SPMCoal	y2x3		
$Wage^2$	x22	SO_2NO_x	y34		

Table 3.3: Shadow Prices of Pollutants

(Rs, per tonne)

Industrial Pollutants	Mean	Standard Deviation
SPM	1043	1067
SO_2	5867	8706
NO_2	11539	21153

3.4 Shadow Prices of Pollutants and Pollution Taxes

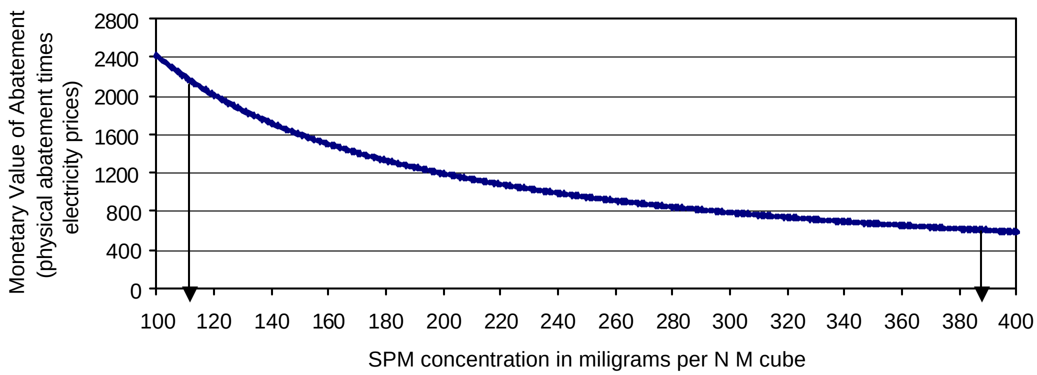
Estimation of pollution taxes using the Taxes-Standards method requires estimates of the marginal cost of pollution abatement and the data about pollution standards. The shadow prices of pollutants estimated in Section 3.2 could be also interpreted as marginal costs of pollution abatement. Using the estimated distance function for thermal power generation in AP, plant specific shadow prices could be calculated. The marginal cost of pollution abatement for each pollutant could be obtained by finding a relationship between the shadow price of the pollutant and pollution load. The marginal cost of pollution abatement of a plant could depend on output, pollution load and plane specific characteristics among others. Specifying this relationship as stochastic, marginal cost of pollution abatement function for APGENCO is estimated each for SPM, SO_2 and NO_x as given in equations 3.6, 3.7 and 3.8 respectively. In these equations, the dependent variables are shadow prices of pollutants (SPMS, SO_2S, NO_xS) and independent variables are electricity output, pollution concentrations (SPMC, SO_2C, NO_xC), plant specific dummy variables (D_i, i = 1…4) and time. There is a rising marginal cost with respect to pollution reduction as expected.

SPM

ln SPMP = 11.82 + 0.255* ln (OUT) – 1.02* ln (SPMC) + 0.705*D1 +0.308*D2 - 0.57*D3
(22.80) (2.92) (-13.71) (2.96) (1.00) (-3.31)
0.108*D4 - 0.22*TIME
(0.55) (13.71) (3.6)
Adjusted R^2 = 0.7822

The following figures depict the marginal pollution abatement cost function for SPM, SO_2 and NOx. On y-axis marginal cost of abatement and on x-axis concentrations of SPM, SO_2 and NOx are measured.

Figuare 3.1: Abatement Function for SPM concentration



<u>SO_2</u>

$\ln SO_2P = 9.33 + 1.012 * \ln(OUT) - 0.835 * \ln(SO_2C) - 02.16 * D1 \quad - 2.27 * D2 \quad - 1.69 * D3$

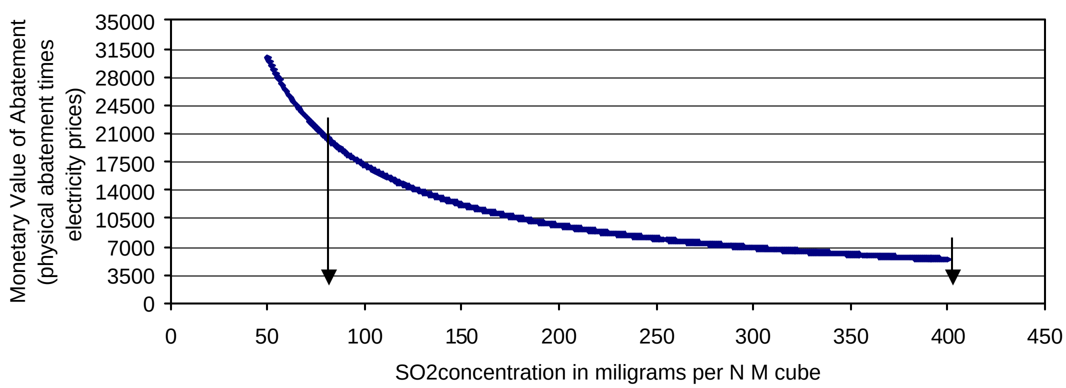
(27.24) (11.73) (-14.85) (-8.37) (-6.68) (-10.13)

$-0.352 * D4 - 0.073 * TIME$

(-1.47) (-3.01) (3.7)

Adjusted $R^2 = 0.8196$

Figure 3.2: Abatement Function for SO2 concentration



<u>NO_X</u>

$\ln NO_XP = 4.94 + 1.21 * \ln(OUT) - 0.63 * \ln(NO_XC) - 3.88 * D1 \quad - 2.41 * D2 \quad - 0.93 * D3$

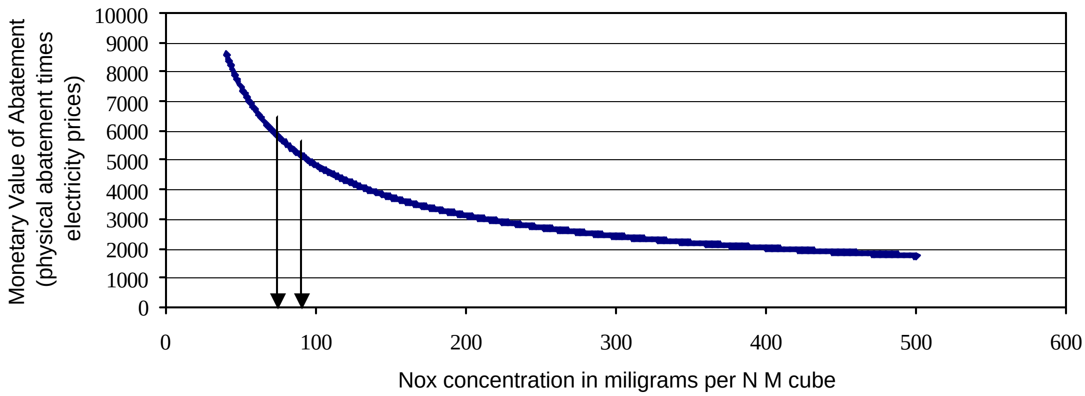
(14.67) (13.48) (-10.67) (-16.58) (-7.50) (-5.23)

$-1.38 * D4 - 0.27 * TIME$

(-6.34) (10.8) (3.8)

Adjusted $R^2 = 0.8062$

Figure3.3:Abatement Function for NOx concentration



Using the above abatement cost of functions and using MINAS Stack Emission Standards of 115, 80 and 80 milligrams per Nm^3 respectively for SPM, SO_2 and NO_x, the tax rates are computed as Rs. 2099, 20519 and 5554.

3.5 Cost of Environmentally Sustainable Industrial Development and Measurement of Green GDP

There is a cost associated with environmentally sustainable development. As explained in Chapter II, the UN methodology of Integrated Environmental and Economic Accounting calls it the maintenance cost or the cost of maintaining the environmental quality at its natural regenerative level. Scientifically, the environmental standards (Minimum National Standards, MINAS in India or WHO standards) are supposed to be designed taking into account the natural regenerative capacity of environment media. Therefore, the cost of complying with these standards to the industry may be interpreted as cost of environmentally sustainable industrial development. This cost has to be accounted in the measurement of Green GDP or environmentally corrected net national product (ENNP). The ENNP could be defined as[3],

$$ENNP = C + P_k \Delta K + P_n \Delta N \quad (3.9)$$

where C, ΔK, and ΔN represent respectively, consumption, changes in manmade capital, and natural capital and P_k and P_n are prices of manmade and natural capital.

[3] See Weitzman (1976), Dasgupta and Maler (1998), and Murty and Surender Kumar (2004).

The first two terms in (3.9) constitute the conventional NNP while the last term accounts for the value of change in natural resource stock (change in environmental quality) due to economic activities during the year. UN methodology suggests the development of physical and monetary accounts of natural capital as satellite accounts to the conventional national accounts for estimating $P_n\ \Delta N$. Time series of physical accounts of ambient quality of atmosphere, and water resources and forest cover has to be developed to estimate ΔN. For example in the case of air pollution studied in this chapter, ΔN could be measured as the excess of pollution load of SPM over the pollution load corresponding to safe ambient standards. In the case of CO_2, ΔN could be simply the pollution load generated because it adds to the stock of CO_2 already present in the atmosphere.

Table 3.4: Physical and Monetary Accounts of Air Pollution for APGENCO

	SPM	SO_2	NO_X
Load (Tonnes/yr.)	7836	10488	1668
Shadow Price (Rs.)	1043	5867	11539
Cost of Abatement (Rs. million)	8.173	61.533	19.247

Note: Row 2 of Table shows the data of observed emissions of SPM, NO_X, and SO_2

Different concepts of environmental values and methods of valuation are discussed in the literature as explained in Chapter II. The price of natural capital (P_k) has to be estimated using one of these methods. The producer value is also called maintenance cost or cost of sustainable use of environment for the producer/polluter, the methodology for its estimation is described in section 3.2. Table 3.3 in Section 3.2 provides estimates of shadow prices of pollutants for the thermal power generation in AP.

Table 3.4 provides physical and monetary accounts of air pollution for a representative firm belonging to AP GENCO during a year. The annual cost of reducing the pollution levels of SPM, SO_2, and NO_x from the current levels to zero in all plants of APGENCO is estimated as Rs. 534 million.

3.6 Conclusion

There is a cost associated with the environmentally sustainable industrial development that is described by the UN methodology of Integrated Environmental and Economic Accounting as the maintenance cost. This cost could be considered as the cost to the industry of complying with the environmental standards fixed taking in to account natural regenerative capacity of environmental media. A method in the theory of production describing pollution as a bad output jointly produced with the good output is used in this paper to estimate the maintenance cost. The panel data of 5 coal fired thermal power plants in Andhra Pradesh state of India for 8 years are used for the estimation.

The shadow prices of pollutants and cost of pollution abatement are estimated for APGENCO. This cost does not account for the cost of CO_2 reductions in thermal power generation that could be very high.

The pollution taxes to make the thermal power plants in AP to comply with the MINAS stack standards are estimated as Rs. 2099, 20519 and 5554 respectively for SPM, SO_2 and NO_x.

IV. A Generalized Method of Hedonic Prices: Measuring Benefits from Reduced Urban Air Pollution

4.1 Introduction

The valuation of environmental services is required for diverse purposes such as for: (a) estimating Green GDP, (b) making investment decisions and (c) designing environmental policy instruments. Environmental values conceptually could be defined as producer values and household values[1]. The UN methodology of Integrated Environmental and Economic Accounting defines producer value or maintenance cost as the cost of sustainable use of environmental resources. A number of valuation methods are suggested in the literature for measuring household values: contingent valuation (CV), household production functions, and hedonic prices. In pollution related studies, all these methods aim at estimating the benefits to the households from reducing exposure to air or water pollution. Therefore, the accurate measurement of household exposure to pollution is an important component of the valuation method. Household members are exposed to different levels of ambient air pollution at home, at office, at school, and on travel. The health benefits of reduced pollution are estimated using CV and health production function methods by measuring household values on reduced total exposure to pollution.

In the case of hedonic prices methods, the hedonic property prices method is used to estimate the benefit to households from reduced pollution at the house location and the hedonic wage model is used to estimate the benefits to a member of the household from the reduced pollution at the work place. The household choices about house location, job location and travel of its members determine the household exposure to pollution. These are interdependent decisions if the household tries to minimize the exposure to pollution through these choices. Therefore, a generalized hedonic prices model considering household decisions about house location, job and travel are interdependent is needed to estimate the environmental benefits from the reduced exposure of households to pollution.

[1] For detailed treatment of producer values see Murty and Kumar (2004), and Murty and Gulati (2004). See for a comprehensive discussion about household values Freeman (1993), Mitchell and Carson (1989), and Murty and Kumar among many others.

This chapter provides a generalized hedonic prices model. An attempt is made to estimate this model using the data collected through a specially designed household survey in the twin cities of Hyderabad and Secunderabad in state of Andhra Pradesh (AP) in India. Household demand function for the air quality and the potential welfare losses from the current air pollution exceeding the safe level in these cities are estimated. It is shown that these welfare losses have to be accounted in the estimation of Green Gross State Domestic Product (GGSDP).

4.2 A General Model of Hedonic prices: Interdependent Individual Choices of Location of House, Travel and Job

Commodities can be distinguished by the characteristics they possess and their prices are functions of these characteristics. From the owner's point of view, land property could be distinguished in terms of location, size, and local environmental characteristics. From the worker's point of view, a job is a differentiated product in terms of risk of on job accident, working conditions, prestige, training, enhancement of skills, and the local environmental quality. From the commuters point of view, travel is a differentiated product in terms of mode of transport, route, distance, time, and on travel exposure to environmental pollution. Rent, wage, and travel cost are respectively functions of the local air quality at home, air quality at work place, and the air quality in the areas through which one travels. Individuals try to minimize exposure to pollution in a day by an appropriate mix of choices of house location, regular travel, and work place depending upon house rent or price, travel cost, and the wage premium for the environmentally risky jobs thus making these choices interdependent.

A Model of Hedonic prices

Hedonic price equations of house, travel and wage are given as follows:

House price equation

$$P = P(H) \tag{4.1}$$

where, P: House price;

H: A vector of house characteristics.

Wage equation

W = W (J), (4.2)

where, W: Wage rate

J: A vector of job characteristics.

Travel cost equation

C = C (T), (4.3)

where, C: Travel cost

T: A vector of travel characteristics.

House characteristics could be described as structural (size of the house), neighbourhood (distance characteristics such as nearness to market, work place, hospital, and school, crime rate, majority local community etc.); and environmental characteristics (local atmospheric and ground water quality, tree cover etc.). Travel characteristics are described as route taken, pollution en route, mode of transport, and time spent on travel. Job characteristics are type of job (blue or white collar), work experience, accidental risk, and exposure to environmental pollution at work.

The household utility function and the budget constraint are defined as

U = U (X, H, J, T), (4.4)

where X is a private good, which is taken as a numeraire.

$I^* + W - X - P - C = 0$, (4.5)

where I^* is non-wage income.

The household chooses H, J, and T by maximizing the Lagrangian

$L = U(X, H, J, T) - \lambda[I^* + W - X - P - C]$. (4.6)

Let E_1, E_2 and E_3 represent the exposure of an individual to pollution while staying at home, traveling and working; on the environmental characteristics of House, Job and Travel.

Conditions for household choices of E_1, E_2 and E_3 along with other choices are:

$$\frac{U_{E_1}}{U_X} = \frac{\partial P}{\partial E_1} \quad (4.7a)$$

$$\frac{U_{E_2}}{U_X} = -\frac{\partial W}{\partial E_2} \quad (4.7b)$$

$$\frac{U_{E_3}}{U_X} = \frac{\partial C}{\partial E_3} \tag{4.7c}$$

The implicit marginal price of environmental pollution is given as:

$$IMP = \frac{\partial P}{\partial E_1} - \frac{\partial W}{\partial E_2} + \frac{\partial C}{\partial E_3} \tag{4.8}$$

If House Job and Travel choices are interdependent; the hedonic prices equations are given as follows:

P = P (H, J, T, W, C) (4.9)

W = W (H, J, T, P, C) (4.10)

C = C (H, J, T, P, W) (4.11)

The conditions for household choices of E_1, E_2 & E_3 along with other choices are given as

$$\frac{U_{E_1}}{U_X} = \frac{\partial P}{\partial E_1} - \frac{\partial W}{\partial E_1} + \frac{\partial C}{\partial E_1} = IMP_1 \tag{4.12a}$$

$$\frac{U_{E_2}}{U_X} = \frac{\partial P}{\partial E_2} - \frac{\partial W}{\partial E_2} + \frac{\partial C}{\partial E_2} = IMP_2 \tag{4.12b}$$

$$\frac{U_{E_3}}{U_X} = \frac{\partial P}{\partial E_3} - \frac{\partial W}{\partial E_3} + \frac{\partial C}{\partial E_3} = IMP_3 \tag{4.12c}$$

The implicit price of environmental pollution is again given as

$IMP = IMP_1 + IMP_2 + IMP_3$. (4.13)

The inverse demand function for environmental quality is derived as

$MWP = MWP (E_1, E_2, E_3, H, J, T, G)$, (4.14)

where G: Socio economic characteristics of the household.

The consumer surplus benefits (compensating or equivalent surplus) of improved environmental quality at home, on travel, and at work are obtained as,

$CS_1 = \int MWP\ \delta E_1$ (4.15a)

$CS_2 = \int MWP\ \delta E_2$ (4.15b)

$CS_3 = \int MWP\ \delta E_3$ (4.15c)

The over all consumer surplus benefits are obtained as

$CS = CS_1 + CS_2 + CS_3$. (4.16)

4.3 Estimation of Model

4.3.1 Model for Estimation

Estimation of hedonic prices model is done by first estimating the hedonic prices function and calculating the implicit marginal prices of characteristics of the commodity and then estimating the marginal willingness to pay function for each characteristic. The marginal willingness to pay function is defined by expressing the household specific implicit marginal price of a characteristic as a function of the characteristics of the commodity and the socioeconomic characteristics of households. Many empirical studies on hedonic prices models show that the Box-Cox transformation of variables yields better model estimates.

The Quadratic Box-Cox Model

$$P^{(\theta)} = \alpha_0 + \sum_{i=1}^{m} \alpha_i X_i^{(\lambda)} + \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \gamma_{ij} X_{i=1}^{(\lambda)} X_{j=1}^{(\lambda)} \qquad (4.17)$$

where P is the price, and X_i's are the characteristics of the commodity and $P^{(\theta)}$, and $X^{(\lambda)}$ are Box-Cox transformations:

$$P^{(\theta)} = \left(P^{\theta} - 1\right)/\theta, \qquad \forall\ \theta \neq 0$$

$$= \text{Ln } P \qquad \theta = 0.$$

$$X_i^{(\lambda)} = \left(X_i^{\lambda} - 1\right)/\lambda \qquad \forall\ \lambda \neq 0$$

$$= \text{Ln } X_i \qquad \lambda = 0.$$

Imposing zero restrictions on θ and λ we can obtain the trans log form attributed to Christensen, Jorgenson and Lau (1971) given by:

$$LnP = \alpha_0 + \sum_{i=1}^{m} \alpha_i LnX_i + \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \gamma_{ij} LnX_i LnX_j .$$

Adding a stochastic term to the quadratic model we get: -

$$P^{(\theta)} = \alpha_0 + \sum_{i=1}^{m} \alpha_i X_i^{(\lambda)} + \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \gamma_{ij} X_{i=1}^{(\lambda)} X_{j=1}^{(\lambda)} + \varepsilon_t \qquad (4.18)$$

The two equations of the hedonic prices model estimated in this paper with Box-Cox transformation of both dependent and independent variables are:

$$P_h^{(\theta_1)} = \alpha_1 + \sum \beta_i X_i^{(\lambda_?)} + u_h \quad (4.19)$$

$$Y_h^{(\theta_2)} = \alpha_2 + \sum \gamma_i X_i^{(\lambda_?)} + \sum \mu_j G_j^{(\lambda_?)} + v_h \quad (4.20)$$

h= 1…..H.

where X_i, i = 1…N and G_j, j = 1…S are respectively the characteristics of commodity and socio economic variables of the household , Y_k is the marginal willingness to pay for the environmental characteristic of the commodity and θ_1 ,θ_2 and λ_1, λ_2 are respectively Box-Cox transformations on dependent and independent variables in the two equations. Since these transformations apply only to positive values of P, Y, X, and G, the constant and the dummy variables are not transformed.

4.3.2 Data

The data used for the estimation are obtained from a specially designed household survey of a sample of households in the cities of Hyderabad and Secunderabad and the secondary data is from the Andhra Pradesh State Pollution Control Board (APPCB) and the Central Pollution Control Board (CPCB). The twin cities have 20 air pollution monitoring stations regularly monitored by the APPCB and collecting data on the concentrations of RSPM, NO_x, and SO_2 in the atmosphere. The sample of 1250 households was distributed among the areas around 20 monitoring stations. The households within a one-kilometre radius of the monitoring station were chosen for the sample. The area around a monitoring station is divided as low income, middle income and higher income localities and a sub-sample of households earmarked for that area is drawn having a representation of each locality. Households earmarked for each locality are selected randomly for the survey. Thus a stratified random sample method is used for choosing a sample of households for the survey.

The present survey conducted during January - February 2004 has collected data about the structural, neighbourhood, and environmental characteristics of houses, the travel characteristics of travel in the city by the members of the household, the job characteristics of working members of the household, and the socio-economic characteristics of households. Table 4.1 and 4.2 provide the descriptive statistics of variables for which data were collected.

Table 4.1: Descriptive Statistics – Hedonic Property Price Model

Name of the Variable	Mean	Standard Deviation
House Ownership	2.5189	0.6745
Number of Floors	1.1977	0.4481
Number of Rooms	3.4723	1.5171
Number of Bathrooms	1.7623	0.9279
Air Cooler	0.4335	0.6855
Air Conditioner	0.1619	0.6579
Connect to Public Sewer	0.9211	0.2728
Water Quality	1.5386	0.5297
Ventilation	0.6944	0.8925
Cooking Fuel	0.9672	0.1781
Business / Salaried	0.3070	0.4615
Religion	0.8784	0.3270
Property Price Enhancing	0.3720	0.4835
Water logging	0.2924	0.4548
Green Cover	0.4366	0.4962
Exposure	0.0529	0.2241
House Age	17.6123	14.3579
Plot Area	1809.039	2155.723
Distance from Business Center	0.9595	0.66008
Distance from Shopping Mall	0.7445	0.4162
Distance from Slum	1.1076	0.4526
Distance from Industries	7.0931	4.1179
Area of Park	192507.6	167488.9
Electricity	23.8274	0.5726
Education	15.0486	7.0756
Income	164098.8	171804.5

Table 4.2: Descriptive Statistics – Hedonic Travel Cost

Name of the variable	Mean	Standard Deviation
Mode of Transport	0.4852	0.5000048
Multiple Mode of Trans	0.1915	0.39363
Car AC or non AC	0.0457	0.20893
Distance Traveled	9.6106	10.2864
Time taken in commuting	0.5832	0.62288
En Route RSPM	84.7494	17.8476
Education	14.6709	4.0394

4.3.3 The Hedonic Property Value Model

Estimates of the hedonic property price equation for the twin cities of Hyderabad and Secunderabad are given in Table 4.3. The estimation is done with the Box-Cox transformation of dependent and independent variables since the null hypothesis of standard values of θ_1 and λ_1 is rejected in favor of unrestricted estimates of θ_1 and λ_1. The coefficients of most of the independent variables in the equation have required signs and are statistically significant. These variables represent the structural characteristics like number of rooms, number of floors, use of air conditioners, ventilation and connection to a public sewer, the distance characteristics like distance from market, and distance from industries, the neighborhood characteristics like majority religion, presence of business class and property price enhancing activities and the environmental characteristics like presence of air pollutants: RSPM, SO_2, and NO_x.

Table 4.3: Parameter Estimates of Hedonic Property Price Equation

Dependent variable: Annual Rent of House.		**Theta = 0.029*, Lambda = 0.123**	
Variables	**Coefficient (Chi Sq)**	**Variables**	**Coefficient (Chi Sq)**
Constant	5.599	Water logging (wlogg)	-0.083* (3.160)
House Ownership (hown)	0.030 (0.952)	Green Cover (gcover)	0.065 (2.212)
Number of Floors (nf)	0.065 (1.859)	Exposure (expos)	-0.088 (0.918)
Number of Rooms (nr)	0.101*** (35.103)	RSPM (rspm12)	-0.182*** (15.558)
Number Bathrooms (nb)	0.203*** (49.034)	SO2 (so12)	-0.432** (4.739)
Air Cooler (a)	0.219*** (38.920)	NOx (nox12)	0.199** (3.855)
Air Conditioner (ac)	0.270*** (38.625)	House Age (hage)	-0.024 (1.907)
Connected to Public Sewer (psew)	0.178*** (5.460)	Plot Area (pa)	0.145*** (95.802)
Water Quality (wq)	0.025 (0.307)	Distance from Business Center (dbs)	-0.336*** (19.148)
Ventilation (ven)	0.096*** (14.019)	Distance from Shopping Mall (dsm)	0.002 (0.001)
Cooking Fuel (fuel)	0.428*** (12.933)	Distance from Slum (dslm)	0.255*** (18.143)
Business or Salaried (bsal)	0.105** (4.140)	Distance from Industries (dia)	0.170*** (45.296)
Religion (rel)	0.250*** (8.446)	Area of Park (apark)	0.044*** (18.614)
Property Price Enhancing (eprop)	0.176*** (16.146)	Electricity (elec)	0.483 (0.818)
Hypothesis Testing against restricted functional forms			Log-likelihood = -2629.955 LR Stat: 1359.47*** R^2 = 0.84
Null-Hypothesis	Restricted Log-likelihood	Chi-Sq	Probability

Theta = Lambda = -1	-14253.983	3247.98	0.000
Theta = Lambda = 0	-12631.628	3.27	0.071
Theta = Lambda = 1	-14302.899	3345.81	0.000

Using the estimated hedonic property price equation, the implicit marginal price of environmental characteristic, RSPM is computed as follows:

$$\frac{\partial RENT}{\partial RSPM} = \frac{RSPM^{\;0.122-1}}{RENT^{\;0.029-1}} \,|\left(-0.182\right)| \qquad 4.21$$

The household marginal willingness to pay function for the environmental characteristic of house is estimated by considering the computed implicit marginal price as function of house characteristics and the socio-economic characteristics of households. Table 4.4 provides the estimated household marginal willingness to pay function for the reduction of RSPM in the local atmosphere. This is also called as inverse demand function for

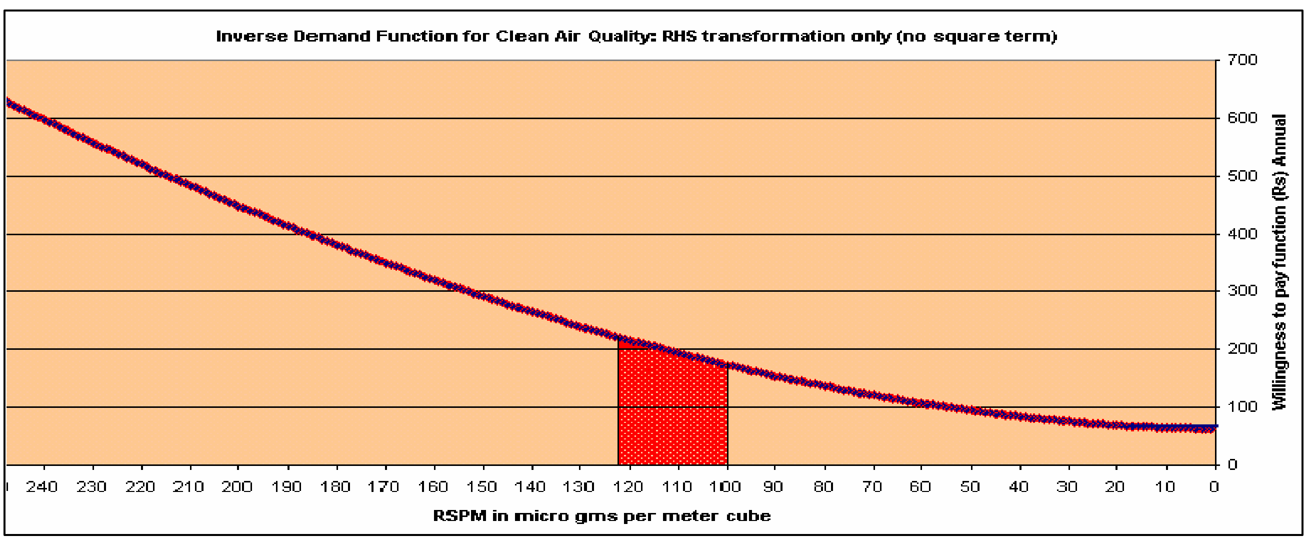
Table 4.4: Marginal Willingness to Pay Function for Environmental Characteristic of Houses

Dependent variable: Marginal Implicit Rent.			**Lambda =1.803*** **
Variables	**Coefficient (Chi Sq)**	**Variables**	**Coefficient (Chi Sq)**
Constant	-502.57	Water logging	-0.9235 (0.001)
Ownership	15.79 (0.491)	Green Cover	-4.6157 (0.021)
Number of Floors	153.51*** (19.344)	Exposure	-24.7554 (0.136)
Number of Rooms	26.77** (4.717)	RSPM	0.0492* (2.650)
Number of Baths	55.89*** (6.780)	House Age	-0.0163 (0.057)
Air cooler	54.44** (4.754)	Plot Area	0.00003*** (14.856)
AC	177.33*** (28.921)	Distance from Business Centre	-50.2476** (4.584)
Connected to Public Sewer	25.07 (0.199)	Distance from Shopping Mall	87.6644* (3.279)
Water Quality	-8.86 (0.087)	Distance from Slum	-66.5810* (3.493)
Ventilation	-1.41 (0.006)	Distance from Industries	0.2008 (0.044)
Cooking Fuel	-59.59 (0.526)	Area of Park	5.46e-08*** (74.028)
Business or Salaried	-36.71 (0.966)	Electricity	0.1271 (0.004)
Religion	-16.18 (0.084)	Education (fedu1)	-0.0802 (0.186)

Property Price Enhancing	132.14 (17.680)	Income (fgross)	1.52e-08*** (35.746)
Hypothesis Testing against restricted functional forms			Log-likelihood = -8700.698 LR Stat: 771.42*** $R^2 = 0.67$
Null-Hypothesis	Restricted Log-likelihood	Chi-Sq	Probability
Theta = Lambda = -1	-8726.6183	51.84	0.000
Theta = Lambda = 0	-8740.074	78.75	0.000
Theta = Lambda = 1	-8715.1921	28.99	0.000

the atmospheric quality revealed through house location choices. Figure 4.1 provides the graph of this function for a representative household of the twin cities. The area under the demand curve provides an estimate of the welfare gains to a representative household from reducing air pollution to zero from the current level. An estimate of annual marginal willingness to pay of a representative household for the reduction of RSPM (reduction of one microgram at margin) at the current maximum level of pollution in the twin cities is obtained as Rs 220.67. The estimate of annual welfare to a typical household from the reduction in RSPM levels from current maximum to a safe level (100µg/C^3) is given as Rs 4,499.72.

Figure 4.1: The Inverse Demand Function for Urban Air quality Revealed Through House Location Choices



4.3.4 Hedonic Travel Cost Model

The hedonic travel cost method could be used to estimate an individual marginal willingness to pay for improvement of urban air quality as revealed through their travel choices. This method that is probably not discussed in the literature on measuring benefits from reduction in urban air pollution so far is empirically interesting for finding the revealed environmental values by exploiting the information about individuals' choices of modes of transport, and travel routes to minimize their exposure to urban air pollution[2]. The per day travel cost of an individual is defined as a function of distance traveled, mode of transport, time taken, and air pollution en route.

The household survey of the twin cities of Hyderabad and Secunderabad described earlier provides data on the travel characteristics of all the working members in the family. There are some households in the sample, which have more than one working member. Table 4.2 provides the descriptive statistics of variables used for estimating the hedonic travel cost function. An individual's exposure to air pollution is measured as the average of ambient pollution concentrations at identifiable landmarks en route. Given that the data on pollution concentration is available only for 20 monitoring stations, the pollution at a given land mark en route is taken as the pollution concentration at the monitoring station nearest to that land mark.

Table 4.5 provides parametric estimates of the hedonic travel cost function. The Box-Cox transformation is done only on dependent variables since the null hypothesis of alternative transformations is rejected in favour of Box-Cox transformation in this case. The coefficients of all independent variables have the required signs and are significant at 1 percent level. As expected, the cost of travel is inversely related to the exposure to air pollution. The individual could be using a longer route or travelling by AC car to minimize exposure to pollution resulting in the higher travel cost.

[2] Pendelson and Madelsohn (2000) have used the hedonic travel cost method for estimating demand for specific environmental characteristics of resource sites by making use of data for a number of sites.

Table 4.5: Parameter Estimates of Hedonic Travel Cost Function

Both sides transformation with same parameter where Lambda = 0.268* **			
Variables	**Coefficients**		
Constant	2.128		
Mode of Transport (amt)	1.032*** (124.487)		
Multiple Mode of Trans (ammt)	0.304*** (8.193)		
Car AC or non AC (aac)	2.445*** (125.979)		
Distance Travelled (adw1)	0.665*** (255.496)		
Time taken in commuting (atswt1)	-0.258** (5.407)		
En Route RSPM (arspmt)	-0.084*** (2.473)		
	Log Likelihood = -3733.149 LR Stat = 625.99*** R^2 = 0.61		
Hypothesis Testing			
H_0	Rest. Log L.	Chi sq	P value
Lambda = -1	-5289.775	3313.25	0.000
Lambda = 0	-3817.815	169.33	0.000
Lambda = 1	-4240.971	1015.65	0.000

The implicit marginal cost of environmental characteristic of travel is estimated in the same way as it is done in the property value model. The marginal willingness to pay function for the air quality en route is estimated by expressing implicit marginal cost as a function of travel characteristics and socio-economic characteristics of the individual. Table 4.6 provides parametric estimates of marginal willingness to pay function or inverse demand function of air quality revealed through an individual's travel choices. The coefficients of most of the independent variables of this function have required signs and are significant at the 5 percent level. The derived demand function for air quality from the travel cost model is given as,

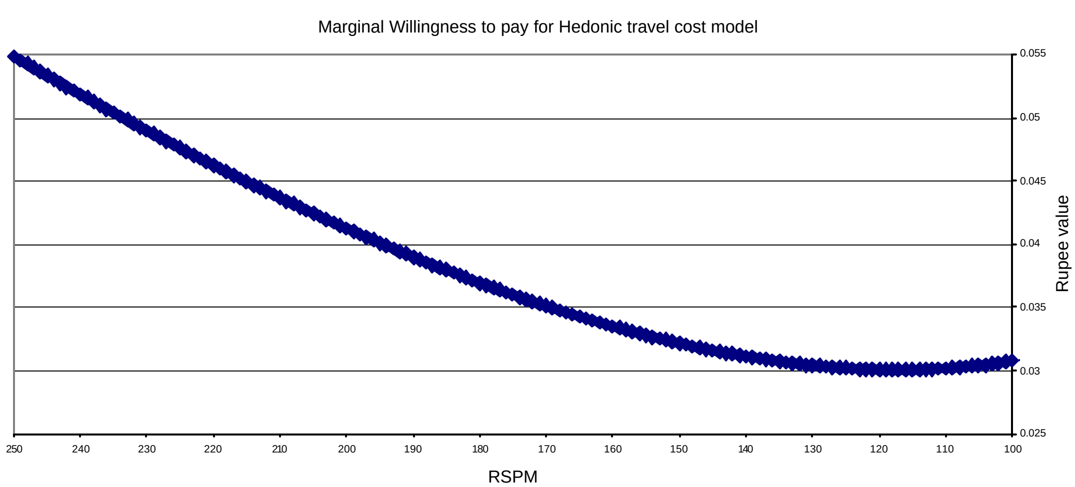
$$\text{Marginal Travel Cost} = 0.1566 – 0.185*((arspmt^{0.429516}-1)/0.429516) + 0.0012*(arspmtsq^{0.429516}-1)/0.425916)). \qquad (4.22)$$

Table 4.6: Parameter Estimates of the Marginal Willingness to Pay Function of Environmental Characteristic of Travel

Only Right Hand Side transformation: Lambda = 0.268* **	
Variables	**Coefficients**
Constant	0.121
Mode of Transport (amt)	0.008 (83.371)
Multiple Mode of Trans (ammt)	0.001 (1.538)
Car AC or non AC (aac)	0.030*** (140.126)
Distance Travelled (adw1)	0.003*** (121.263)
Time taken in commuting (atswt1)	-0.0008 (0.442)
En Route RSPM (arspmt)	-0.019*** (32.432)
RSPM square (arspmtsq)	0.001*** (3.712)
Wage (awage)	0.0001*** (87.442)
Education (awem1)	-0.001** (3.712)
	Log Likelihood = 2961.5281 LR Stat = 864.84*** R^2 = 0.84

Hypothesis Testing			
H_0	Rest. Log L.	Chi sq	P value
Lambda = -1	-5289.775	3313.25	0.000
Lambda = 0	-3817.815	169.33	0.000
Lambda = 1	-4240.971	1015.65	0.000

Figure 4.2: Inverse Demand Function for Urban Air Quality Revealed Through Travel Choices



This function has required the curvature property in a certain range of the variable air pollution as shown in figure 4.2 By integrating the function in the range of maximum RSPM (122μ / C^3) en route to the safe level (100μ / C^3) an estimate of welfare gain to a representative commuter by reducing air pollution to the safe level in the twin cities could be obtained. A typical commuter gets a daily benefit of Rs7.27 due to the reduction of RSPM from the maximum level to the safe level and an annual benefit of Rs 2,108[3]. There are on the average 1.538 working members in the sample households. Therefore, a representative household in the twin cities gets an annual benefit of Rs 3243 from reducing exposure to air pollution to the safe level on travel of its members

4.3.5 Welfare Gains for Households in the twin Cities from Reduced Air Pollution to Safe Levels

The working members of a typical household in the twin cities spend 13.4 hours at home, 1.16 hours on travel and the remaining hours at the work place or in leisure activities. As explained in Section 4.2, household members are exposed to air pollution while staying at home, travelling in the city and working in office. The household willingness to pay for reduced pollution is the sum of its willingness to pay for reduction of pollution at all these places. In Section 4.3, estimates of the annual household willingness to pay for reduction of air pollution to the safe level at home and on travel are obtained as Rs 4,500 and Rs 3,243, respectively. The data on job characteristics of working members of the family collected through the household survey does not explain any revealed values for air quality at the work place. Survey data shows that most of these members are have white-collar jobs, the choice of which is not affected by the air quality at the work place. Therefore, the total annual willingness to pay of a typical household for reducing air pollution to the safe level is Rs 7,743. The gains for all the households in the twin cities as per the 2001 Census (provisional) are estimated as Rs 6,437 million. The damages from air pollution in the twin cities constitute 0.0423 percent of State Domestic Product (SDP) of Andhra Pradesh in 2003 and the SDP corrected for air pollution is given as Rs 15,12,523 million.

[3] Annual benefits are estimated assuming that individuals work 290 days in a year.

4.4 Environmental Values of Households, Resource Depletion and Shadow Prices

Some recent studies in India (Murty, Gulati and Banerjee, 2004; Murty and Gulati, 2005) including the study reported earlier in this chapter provide estimates of household marginal willingness to pay function for urban air quality improvement in the cities of Delhi, Kolkata and Hyderabad using the hedonic property value method of environmental valuation. Table 1 provides an estimate of the household marginal willingness to pay function for reduction in Total Suspended Particulate Matter (TSPM) in Delhi while Figure 1 provides the graph of this function. This function shows that a typical household in Delhi is willing to pay Rs. 152 annually for one micro gram reduction of atmospheric concentration of TSPM. A recent study by Sudhakar Yedla et al. (2002) has done urban air quality modeling for the cities of Delhi and Mumbai for finding the relationship between the emissions from different sources and the ambient air quality in the city. This study makes an estimate of reduction of TSPM by 2.37 thousand tonnes from the transport sector in Delhi in comparison to the business as usual scenario in the year 2005 due to introduction of CNG in all buses and small cars. This intervention results in a 30 per cent reduction of contribution of transport sector to the ambient air pollution, measured as TSPM concentration in a cubic meter. An average of the estimates of contribution of the transport sector to the hourly ambient concentration of SPM at seven monitoring stations in Delhi in the business as usual scenario works out to be $0.75\mu / m^3$. A 30 per cent reduction of it amounts to $0.215\mu / m^3$. Therefore, an estimate of reduction of ambient pollution of TSP in Delhi due to one tonne reduction of TSP at sources works out to be mg $0.00009\mu / m^3$. Now the household annual willingness to pay for this reduction becomes Rs 0.014 and extrapolating it to the estimated 2347942 urban households in Delhi, the shadow price of a tonne of TSPM becomes Rs. 32871.

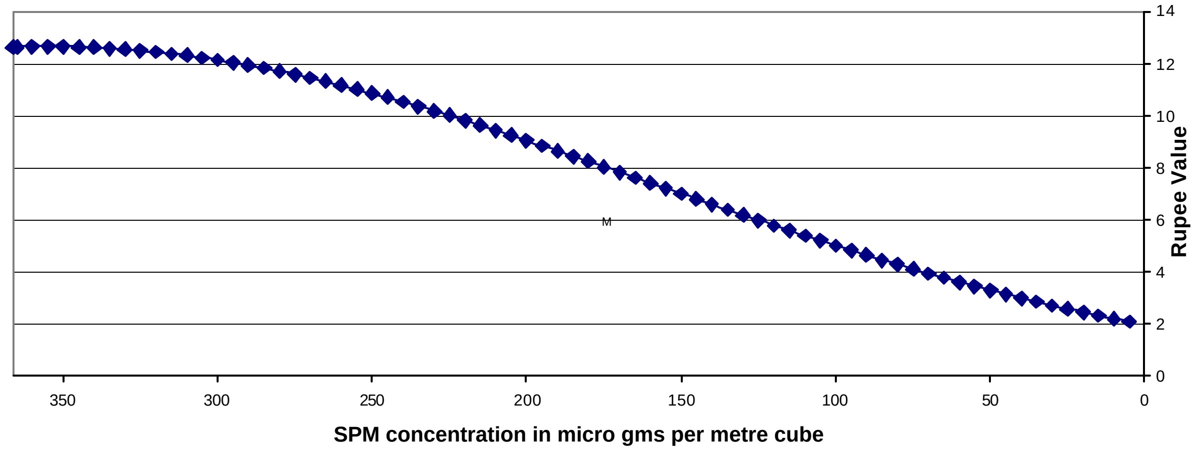
Urban air pollution is an environmental externality created by polluters and therefore the shadow price of air pollution defined above depends upon the size of the exposed population to pollution. For example, a typical urban settlement in India has a population of one million with 2.5 lakh households. It is important to see what is the shadow price of a tonne of TSPM if 2.5 lakh households are exposed to air pollution levels currently found in the mega cities of Delhi, Mumbai, Kolkata, and Hyderabad etc. The studies mentioned above (Murty, Gulati and Banerjee, 2004; Murty and Gulati, 2005) also provide estimates of the household marginal annual willingness to pay for the reduction of TSPM in the cities of Kolkata and Hyderabad as Rs. 96.76 and Rs. 220.67 respectively. Given these estimates, the average of household marginal willingness to pay for the reduction of TSPM for the three cities could be computed as Rs. 156.33. The shadow price of one tonne of TSPM in an urban area having one million population in India is estimated as Rs. 3525.

Table 4.7: Estimates of Marginal Willingness-to-pay Equation for Delhi

Log Values of Variables (Expected Sign)	Box Cox Transformation $\theta = 0.0736085$**
	Coefficients (Chi^2 statistics)
Constant	-0.5406424
Education X_{18} (+)	0.0316471*** (53.814)
Income X_{19} (+)	2.6e-06*** (294.164)
SPM X_{13} (+)	0.0117879*** (71.954)
Sq SPM X_{20} (-)	-0.0000166*** (90.493)
Perception about Air Quality X_{10} (+)	0.1780826*** (43.498)
	Sigma = 0.5686012
Uncentred R^2 = 0.555	LR chi ^{2} (5) = 658.27 Probability > Chi^2 = 0.000
	Log Likelihood = -3707.6189
Test H_0	Chi ^{2} Statistics
$\theta = -1$	1284.85***
$\theta = 0$	5.28**
$\theta = 1$	725.40***

Source: Murty, Gulati and Banerjee (2004)
Note: *(**) & (***) denotes significance at 10 (5) & (1) % levels

Figure 7.3: Inverse demand function for clean air in Delhi



Source: Murty, Gulati and Banerjee (2004)
Note: The graph is generated from the Current average level of SPM of 366.31 μ gm/m^3 to zero SPM, while the safe limit for SPM concentration is 200 μ gm/m^3.

4.5 Conclusion

Individuals are exposed to air pollution while staying at home, traveling in the city and working at a place. The hedonic property price model is used to estimate benefits individuals get from the reduced pollution at home and the hedonic wages model is used to the estimate benefits from reduced pollution at the work place. The paper suggests that the hedonic travel cost method could be used to estimate benefits to individuals from the reduced exposure to pollution in travel within the city. The individual's marginal willingness to pay for reduced pollution in the city is a sum of the marginal willingness to pay for reduced exposure at home, in travel and at the work place.

Hedonic property prices and the hedonic travel cost models are estimated using data collected through a survey of households in the twin cities of Hyderabad and Secunderabad in the state of Andhra Pradesh in India. Since the survey collects data mostly for people engaged in white-collar jobs, it is found that the air pollution at the work place has no effect on job choices. Estimates show that the annual willingness to pay for reducing air pollution to the safe level of a typical household revealed through its house location and travel choices is Rs 7,743. The damages from the current pollution level for all the households in the twin cities as per 2001 Census (provisional) are estimated as Rs 6,437 million which forms 0.0423 percent of State Domestic Product (SDP) of Andhra Pradesh in 2003.

Using the available estimates of household willingness to pay for the improvement of urban air quality and air quality modeling in India, a method of estimating the household willingness to pay for a unit reduction of air pollution at source is described. For example, the shadow price of one tonne of TSPM in an urban area having one million population in India is estimated as Rs. 3525.

V. Estimating Cost of Air Pollution Abatement for Road Transport in India: Case Studies of Andhra Pradesh and Himachal Pradesh

5.1 Introduction

Transport, especially the road transport is one of most air polluting activities in the economy. Burning of fossil fuels by vehicles contribute air pollution loads in the form of Carbon Monoxide (CO), Hydrocarbons (H), Nitric Oxide (NO_x) and Particulate Matter (PM). For example a passenger car without an emission reduction technology (pre Euro technology) emits 0.0002 kilograms (kgs) of PM and 0.0009 kgs of NO_x per every kilometer (km) distance traveled[1]. The pollution concentration in the atmosphere particularly in the metropolitan areas in India has been much above the safe standards due to a phenomenal growth of traffic demand in India during the recent years. The number of vehicles on roads have increased from mere 306 thousands in the year 1951 to 58863 thousands in the year 2002 as shown in Table A5.2 in Appendix A5. Currently roads carry 85 percent of the passenger and 70 percent of the freight traffic of the country.

Some recent estimates show that a passenger car travels on the average 30-35 kms per day in India[2] and there are about 7571 thousand cars on road. The per day pollution loads of PM from the passenger cars without an emission reduction technology is estimated as 62.25 thousand kgs. In contrast, the technology of emission reduction corresponding to EURO II norms provides for the reduction of PM emissions of cars to 0.00001 kgs per km traveled. That means if all the cars operating on roads in India comply with the EURO II norms, the pollution load of PM reduces from 62.25 thousands to 9.27 thousand kgs per day. The physical accounts of air pollution loads from the transport sector in India could be estimated as loads with and without emission reduction technologies. Tables A5.1 provide these estimates for different pollutants and for different vehicle types in India.

Monetary accounts of air pollution abatement from the transport sector in India could be developed given the physical accounts described above if there are estimates of cost of

[1] See Table A2 for information about other vehicles.
[2] See the Expert Committee on Auto Fuel Policy (Mashlekar, 2002).

pollution abatement per km traveled for different vehicles. Two methods are suggested in this paper for estimating the cost of pollution abatement of vehicles. One method describes that the pollution abatement cost of a vehicle consists of cost of pollution abatement technology used and the incremental cost of producing fuels compatible with this technology. Another method prescribes the estimation of abatement cost incurred by the vehicle owners/users implicit in the choice of vehicles having different characteristics determining the vehicular pollution. Estimation of hedonic travel cost function is suggested by considering the travel cost of vehicle users as a function of vehicle characteristics such as the technology of air pollution abatement and type of fuel used, distance traveled annually and the size of the vehicle. Data of vehicular traffic in two states of India, Andhra Pradesh and Himachal Pradesh , are used to estimate the air pollution abatement cost of different vehicles. There is no specific academic consideration for choosing these two states for this study except the requirement of the research project funded by the Central Statistical Organization (CSO), Government of India[3].

5.2 Emissions and Air Pollution Abatement Technologies

Vehicular Technologies in India have seen improvement only in the recent years. Vehicles with old technologies (Pre EURO) constitute a large number, though the vehicle age in major cities is reducing. There is an urgent need to reduce vehicular emissions. In this context, the Expert Committee on Auto Fuel Policy (Mashlekar, 2002) has recommended an Auto Fuel Policy to address the issues of vehicular emissions, vehicular technologies, and auto fuel quality in a cost efficient manner. It recognizes that efficient transport is an essential service and it is also conscious of the health implications and social costs of automobile emissions and the need to neutralize the costs to the extent it is feasible. The Committee puts forth that the primary requirement of the Auto fuel policy is to formulate measures that will help reduce auto emissions and improve air quality. Upgrading auto fuel quality and vehicular technology to levels that are compatible with the emission norms are crucial components in any strategy that aims at reducing auto emissions and improving air quality. Particularly, investments are needed to enable the

[3] Murty and Gulati (2005)

automobile industry to produce vehicles that are compatible with the recommended emission norms. In this context, the report provides estimates of investments that are needed by the automobile industry and oil producing companies in India. In the past two decades, investments have been made in the infrastructure, design and development of vehicles. With the commencement of the formal emission standards for vehicles in 1991, a number of steps have been taken to improve the energy efficiency of vehicles and reduce their environmental effects. Some emission norms were there in India before the year 2000 which are known as pre Euro norms. Bharat Stage I norms or EURO I norms were introduced in April 2000 for all new vehicles. Bharat Stage II norms or EURO II were introduced in Delhi in the year 2000 and were extended to other metro cities in the year 2001. Bharat Stage III or EURO III norms are currently being considered for all the vehicles. Table 5.1 provides information about these norms.

The air pollution abatement cost of vehicles to comply with the prescribed emission standards has two components. They are the additional cost of switching to new vehicular technology and the incremental cost of producing auto fuels compatible with this technology. The Society of Indian Automobile Manufacturers (SIAM) has provided estimates of incremental costs for the manufacture of vehicles that are compatible with Euro II and Euro III norms as given in Table 5.2. The Energy Research Institute (TERI), which undertook a study on `Incentives for Cleaner Automobiles' has also estimated the incremental costs to be incurred by the manufacturers for producing Bharat Stage II and Euro III equivalent emission compatible vehicles, which are given in Table 5.3. For example, the estimates of TERI show that the incremental cost of adopting new technology of passenger cars for realizing the EURO III norms as Rs. 50 thousands while the same for buses as Rs. 163 thousands. Tables 5.4 and 5.5 provide estimates of incremental production costs to refineries of different vintages in India for producing petrol and diesel of improved quality compatible with the Euro norms. These estimates show that the incremental production cost of a litre of petrol or diesel compatible with the EURO III vehicular technology is as high as Rs. 4 for some refineries in India.

Table 5.1: Emission Coefficients of Various Pollutants (CO, NO_X, HC AND PM) Corresponding to Different Emission Technologies

Emission Coefficients (Kg/Km)						
Pre Euro (1991-95)	**Buses**	**Trucks**	**PCG**	**PCD**	**2W**	**LCV (Tractor, water carrier)**
CO	0.0055	0.006	0.0098	0.0073	0.0065	0.0087
HC	0.0018	0.002	0.0017	0.00037	0.0039	0.00034
NOX	0.019	0.01	0.0018	0.00277	0.00003	0.00315
PM	0.003	0.002	0.00006	0.00084	0.00023	0.0008
Pre Euro (1996-00)						
CO	0.0045	0.005	0.0039	0.0012	0.004	0.0069
HC	0.0012	0.001	0.0008	0.00037	0.0033	0.00028
NOX	0.0168	0.008	0.0011	0.00069	0.00006	0.00249
PM	0.0016	8E-04	0.00005	0.00042	0.0001	0.0005

Emission Coefficients (Kg/Km)						
Euro 1/India stage 2000	**Buses**	**Trucks**	**PCG**	**PCD**	**2W**	**LCV (Tractor, water carrier)**
CO	0.0036	0.0036	0.0024	0.0011	0.0022	0.0051
HC	0.00097	0.00097	0.00048	0.00025	0.00213	0.00014
NOX	0.0126	0.0063	0.00039	0.00059	0.00006	0.00128
PM	0.00056	0.00028	0.00004	0.00014	0.00005	0.0002
Euro 2/Bharat Stage 2						
CO	0.0032	0.0032	0.0022	0.001	0.0015	0.00072
HC	0.00087	0.00087	0.00035	0.00014	0.001425	0.000063
NOX	0.011	0.0055	0.00015	0.00056	0.000075	0.00059
PM	0.00024	0.00012	0.00003	0.00008	0.00005	0.00007

Emission Coefficients (Kg/Km)					
Euro 3/ Bharat Stage 3	**Buses**	**Trucks**	**PCG**	**PCD**	**LCV (Tractor, water carrier)**
CO	0.0028	0.0028	0.00139	0.00058	0.00064
HC	0.00077	0.00077	0.00015	0.00005	0.000056
NOX	0.01	0.005	0.00012	0.00045	0.0005
PM	0.00023	0.0001	0.00002	0.00005	0.00005

Source: Transport Fuel Quality, 2005, Central Pollution Control Board (CPCB), Delhi

Table5.2: Incremental Cost of Bharat Stage II and Euro III Equivalent Vehicles

VEHICLE CATEGORY	CONVERSION	INCREMENTAL COST/VEHICLE (Rs. Lakh)
Passenger car	Bharat II to Euro III	0.5
Trucks	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	1.25 2.25
Buses	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	1.25 2.25
Two and Three Wheelers	Bharat 2000 to Euro III	0.05-0.10

Source: SIAM.

Table 5.3: Incremental Cost of Bharat Stage II and Euro III Equivalent Vehicles

VEHICLE CATEGORY	CONVERSION	INCREMENTAL COST/VEHICLE Rs.Lakh)
Passenger car	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	0.3 0.5
Trucks	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	0.61 1.62
Buses	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	0.61 1.62
Two Wheelers	Bharat 2000 to Euro III	0.35-0.52
Three Wheelers	Bharat 2000 to Euro III	0.55

Source: TERI

Table 5.4: Incremental Production Cost for Petrol

Sl. No.	Refineries	BIS-2000 to *Bharat Stage II* Rs./litre	BIS-2000 to *Euro III* Rs./litre
1	IOCL, Digboi	1.38	4.03
2	IOCL, Barauni	1.71	3.20
3	IOCL, Halda	0.60	1.45
4	IOCL, Gujarat	1.00	2.35
5	IOCL, Mathura	1.11	1.94
6	ICOL, Panipat	0.80	1.71
7	HPCL, Mumbai	2.80	3.95
8	HPCL, Vaiskh	1.50	4.00
9	BPCL, Mumbai	0.50	2.10
10	KRL. Kochi	0.98	3.17
11	CPCL, Chennai	1.50	1.80
12	BRPL, Bongaigaon	Nil*	3.90
13	RPL, Jamnagar	Nil*	0.60
14	MRPL, Managalore	Nil*	2.50
*Have set up Facilities for *Euro II* equivalent			
Source : Ministry of Petroleum and Natural Gas			

Table 5.5: Cost Incremental Production for Diesel

Sl. No.	Refineries	BIS-2000 to *Bharat Stage II* Rs./litre	BIS-2000 to *Euro III* Rs./litre
1	IOCL, Digboi	3.35	4.11
2	IOCL, Guwahati	2.50	2.70
3	IOCL, Barauni	1.60	2.10
4	IOCL, Gujarat	0.84	1.03
5	IOCL, Halda	1.16	1.24
6	IOCL, Mathura	1.23	1.41
7	ICOL, Panipat	0.83	0.93
8	HPCL, Mumbai	1.40	2.00
9	HPCL, Vaiskh	1.50	2.00
10	BPCL, Mumbai	1.50	2.40
11	KRL. Kochi	0.73	2.15
12	CPCL, Chennai	1.30	1.60
13	BRPL, Bongaigaon	1.90	2.20
14	NRL, Numaligarh	0.51	0.98
15	RPL, Jamnagar	0.25	0.90
16	MRPL, Managalore	1.00	1.10

Notes: (i) Import parity premium differential between BIS-2000 and Bharat Stage II petrol and diesel, inclusive of 20% customs duty, is 20 paise per litre and 40 paise per liter (approx.)
(ii) Import parity premium differential between BIS-2000 *and Euro III equivalent petrol and diesel, inclusive of*20% customs duty, is Rs. 1.35 & Rs. 1.50 per litre (approximately)
Source: Ministry of Petroleum and Natural Gas

Estimation of Green GDP for a country using the United Nations Methodology of Integrated Environmental and Economic Accounting (UN, 1993; Murty, James and Mishra, 1999; Murty and Kumar, 2004) requires the development of physical and monetary accounts of environmental changes for different sectors of the economy. Case studies of road transport sectors of Andhra Pradesh and Himachal Pradesh states in India attempted in this paper require the preparation of annualized physical and monetary accounts of air pollution for the road transport sector in each state. Given the data of emission coefficients for pre and post EURO vehicular technologies and the distance traveled and number of vehicles for each type of vehicle, the physical accounts of air pollution for the road transport sector in the form of annual flows could be estimated for pre and post EURO scenarios as described in the next section. Two methods are used to develop the monetary accounts of air pollution. In one method, the annual cost of air pollution abatement for a vehicle is estimated by annualizing the incremental capital cost of changing the technology and the additional cost for using the fuels compatible with the new technology as described in Section IV. Another method described in Section V uses the hedonic travel cost method for estimating the annual cost of air pollution abatement for each type of vehicle.

5.3 Physical Accounts of Air Pollution from Road Transport for Andhra Pradesh and Himachal Pradesh States

Physical accounts of air pollution from the road transport in the two states corresponding to various norms described above could be developed. In fact, using the data on number of vehicles in a state, emission coefficients and distance traveled by each vehicle, one can compute the physical load of each of the pollutants (CO_2, Hydro Carbon, NO_x, and SO_2). It is important to note that emission coefficients are prescribed for CO (carbon monoxide), and hence using the atomic weight of carbon (=12) and oxygen (=16), one can calculate the equivalent load of CO_2 from the pollution load of CO.

Andhra Pradesh:

The data on the number of vehicles plying on the road in each district is obtained from Statistical Abstract of Andhra Pradesh, which gives district-wise number of motor vehicles of different classes and categories registered and on road in the state. Also, average distance traveled per day by each type of vehicle is obtained from Urban Road Traffic and Air Pollution report on Hyderabad. The report gives figures as per outer cordon surveys and fuel station surveys[4]. For district Hyderabad, the study uses the latter whereas for all other 22 districts, outer cordon survey figures have been used. Since the classification of vehicles into different categories is different in the Statistical Abstract Report and the Traffic and Air Pollution Report, certain assumptions have been made in this regard. For calculating the distance traveled by Goods vehicles, a weighted average of the distance traveled by LCV (Light Commercial Vehicle), HCV (Heavy Commercial Vehicle) and MCV (Medium Commercial Vehicle) have been taken, with the weights being the number of observations for each category of vehicle. Tractors have been assumed to be in the LCV category, taxicabs as OBC (old brand cars) and motorcars and jeeps as a mix of OBC and NBC (new brand cars), thus taking a weighted average of the distance traveled by an OBC and a NBC.

Data on emission factors for different categories of vehicles for each of the pollutants, CO, NO_X, HC and PM is obtained from Transport Fuel Quality Report, Central Pollution Control Board (CPCB). However, since the emission factors are available for a few broad heads namely, two-wheelers, three wheelers, PCD (Passenger Cars – Diesel), PCG (Passenger Car – Gasoline), LCV, buses and trucks, the present study has assumed the emission factors of all Goods vehicles and certain non-transport vehicles (as classified in the Statistical Abstract) such as rigs, cranes, road-rollers, fire engines etc. to be the same as that of trucks. Also, for motorcars, emission factors for PCG and for jeeps, emission factors for PCD have been used.

As regards the methodology, to arrive at the emission of a specific pollutant from a particular category of vehicle, say trucks, one can multiply the emission factor for trucks with the total distance traveled by trucks in a day in each district. Also, an estimate of the

[4] In Outer Cordon Surveys, a total of 7 outer cordon points were selected around Hyderabad and classified traffic volume counts along with road side interviews were conducted on sampling basis for 24 hours at each of these locations. In Fuel Station Surveys, a total of 15 fuel stations out of 150 stations located in Hyderabad have been selected to conduct interviews of the owners/drivers of vehicles visiting the fuel stations for collecting the fuel. The survey has been conducted round the clock at stations, which were in peripheral areas because the traffic passing through this area is likely to fill fuel at these stations during night hours. In the city, the survey has been conducted for a period of 12 hours.

total distance traveled is obtained by multiplying the number of trucks plying in each district with the average distance traveled per day by a truck. It is thus possible to arrive at emissions from each category of vehicle for each district and for the state as a whole as also the estimate of total emission of a pollutant for each district and for the entire state.

Similarly, using emission factors corresponding to EURO II norms, total emissions of various pollutants according to the norms can be generated. The difference between the actual emissions and the emissions according to the norms gives us an estimate of the pollution load to be reduced as per the given norm. Table 5.6 provides estimates of pollution loads from the vehicular traffic in Andhra Pradesh state during the year 2001-02.

Himachal Pradesh:

Data on number of vehicles has been obtained from the Transport Commissioner's Office in Shimla, and the information on distance traveled by different vehicles has been obtained from the primary survey of vehicles conducted in Shimla[5]. Taking the average distance from a sample of 100 vehicles of each category, and multiplying by the emission coefficient of say, CO_2, gives us the per day emissions of CO_2 from a vehicle, which can then be extrapolated for obtaining total emissions of CO_2 by further multiplying by the total number of vehicles in the state. Table 5.7 provides estimates of pollution loads by vehicular traffic in Himachal Pradesh during the year 2002-2003

Table5.6: Pollution Loads by Vehicular Traffic in Andhra Pradesh

		CO2	*HC*	*NOX*	*PM*
Pollution Load (Tones /Year)	*Pre Euro*	369463.9	148887.7	45556.2	9285.2
	Euro II / Bharat II	147389.8	70309.7	30402.7	3157.9
Load Reduced/ Physical Accounts (Tones /Year)	*Pre Euro to Euro II*	222074.1	78578	15153.6	6127.3

[5] For details of vehicular survey in Himachal Pradesh see Section V.

Table 5.7: Pollution loads by Vehicular Traffic in Himachal Pradesh

		CO2	*HC*	*NOX*	*PM*
Pollution Load (Tones /Year)	*Pre Euro*	49626.5	9220	24248	2920
	Euro I / Bharat 2000	22829.2	5822	16150	940
	Euro II/ Bharat II	17967	4181	13651	452
Load Reduced/ Physical Accounts (Tones /Year)	*Pre Euro to Euro I*	26793	3396	8097	1977
	Pre Euro to Euro II	31657.2	5038	10596	2.47
	Euro I to Euro II	4862	1640	2497	4872

5.4 Monetary Accounts of Air Pollution

The cost of pollution abatement or the cost of vehicles complying with the emission norms (Euro norms) consists as explained in Section 5.2 the cost of change of vehicle technology and the cost of improving the fuel quality. The estimates of capital cost of air pollution abatement of different vehicles complying with Euro norms given by TERI and SIAM studies could be used to estimate the per vehicle annual cost of air pollution abatement from the change in vehicular technology. The capital cost of changing vehicle technology could be annualized using the interest rate at which the commercial banks in India are lending currently which is about 10.625 percent during the year 2003-2004. Table 5.8 provides these estimates for different types of vehicles. Estimation of the second component of air pollution abatement cost of a vehicle, the cost of improving the fuel quality compatible with the Euro norms, requires data about the incremental production cost of improving the quality of fuels, distance traveled by the vehicle per liter of fuel, and the distance traveled by the vehicle per day. Report of Expert Committee on Auto Fuel Policy (Mashlekar Committee, 2002) provides estimates of incremental production cost of improving the quality of petrol and diesel that is compatible with the Euro norms for refineries of different vintages in India as given in Tables 5.4 and 5.5 in Section 5.2. These estimates form a range of Rs. 0.50-2.80 and Rs.0.60-4.03 per litre petrol respectively for Bharat Stage II and Stage III technologies. Similarly, for diesel they form ranges of Rs. 0.25-3.35 and Rs. 0.90-4.11 for these technologies. The vehicular survey in Shimla described in Section 5.5 provides estimates of kms traveled per a litre of fuel used, and the average distance per day traveled by different vehicles. Also Mashlekar Committee provides estimates of an estimate of distance traveled per day by different vehicles in Andhra Pradesh. These estimates are used to estimate the incremental fuel cost consumed per day by different vehicles in AP and HP as given in Tables 5.11 and 5.12. Tables 5.13 and 5.14 provide estimates of incremental annual cost of different vehicles in AP and HP due to the increased cost of fuel from the improvement of fuel quality as per the Euro norms.

Table 5.8: Annualized Incremental Cost of Investment per Vehicle for Improving Vehicular Technology as per Euro Norms Based on TERI Estimates of Investment Cost

VEHICLE CATEGORY	CONVERSION	ANNUALISED COST/VEHICLE (Rs.)
Passenger car	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	3187.5 5312.5
Trucks	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5
Buses	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5
Two Wheelers	Bharat 2000 to Euro III	4621.87
Three Wheelers	Bharat 2000 to Euro III	5843.75

With the help of information on number of vehicles operating on road in a year for each of the above vehicle categories, one can estimate the total annualized cost of conversion (from one technology to another) of different vehicles operating in a state. Tables 5.9 and 5.10 provide the estimates of annualized cost of investment for converting the vehicular technology as per Euro norms respectively in AP and HP.

Table 5.9: Total Annualized Cost of Conversion of Technology of Different Vehicles Operating in Andhra Pradesh

Vehicle Category	CONVERSION	Annualized Cost/Vehicle (Rs.)	No. Of Vehicles on road 2001-02	Total Annualized Cost 2001-02 (Rs.)
Passenger car	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	3187.5 5312.5	370398	1180643625 1967739375
Trucks	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5	160185	1038199031 2757184313
Buses	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5	215769	1398452831 3713923913
Two Wheelers	Bharat 2000 to Euro III	4621.87	3609373	16682052788
Three Wheelers	Bharat 2000 to Euro III	5843.75	171834	1004154938

Table 5.10: Total annualized Cost of Conversion of Technology of Different Vehicles Operating in Himachal Pradesh

Vehicle Category	CONVERSION	Annualized Cost/Vehicle (Rs.)	No. Of Vehicles on road 2002-03	Total Annualized Cost 2002-03 (Rs.)
Passenger car	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	3187.5 5312.5	63249	201606187.5 336010312.5
Trucks	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5	37805	245023656.3 650718562.5
Buses	Bharat 2000 to Bharat Stage II Bharat 2000 to Euro III	6481.25 17212.5	4417	28627681.25 76027612.5
Two Wheelers	Bharat 2000 to Euro III	4621.87	149286	689980484.8
Three Wheelers	Bharat 2000 to Euro III	5843.75	2611	15258031.25

Table 5.11: Incremental Production Cost of Fuel for Different Vehicles in Andhra Pradesh (Rs/day)

Vehicle Category		*Pre Euro to Bharat Stage II / Euro II*	*Pre Euro to Bharat Stage III / Euro III*
PC	High	6.22	8.95
	Low	1.11	1.33
Bus	High	33.03	40.52
	Low	2.46	8.87
Truck	High	36.72	45.05
	Low	2.74	9.87
Jeep	High	11.78	14.46
	Low	0.88	3.17
Two Wheeler	High	2.70	3.89
	Low	0.48	0.58
Commercial Vehicles	High	16.38	20.10
	Low	1.22	4.40

Table 5.12: Incremental Production Cost of Fuel for Different Vehicles in Himachal Pradesh (Rs/day)

Vehicle Category		*Pre Euro to Bharat Stage II / Euro II*	*Pre Euro to Bharat Stage III / Euro III*
PC	High	6.10	8.77
	Low	1.09	1.31
Bus	High	154.69	189.79
	Low	11.54	41.56
Truck	High	147.81	181.34
	Low	11.03	39.71
Jeep	High	34.70	42.57
	Low	2.59	9.32
Two Wheeler	High	2.40	3.45
	Low	0.43	0.51
Commercial Vehicles	High	62.34	76.48
	Low	4.65	16.75

Table 5.13: Annualized Cost of Vehicles for Using Fuels Compatible with Euro Norms in AP

Vehicle Category	Pre Euro to Euro II		Pre Euro to Euro III	
	Per Vehicle Cost	Total Cost	Per Vehicle Cost	Total Cost
PC	1338	495505110	1877	695208525
Bus	6477	1397615216	9014	1945014480
Truck	7202	1153651249	10023	1605497412
Two Wheeler	581	2097546333	815	2942921044

Table 5.14: Annualized Cost of Vehicles for Using Fuels Compatible with Euro Norms in HP

Vehicle Category	Pre Euro to Euro II		Pre Euro to Euro III	
	Per Vehicle Cost	Total Cost	Per Vehicle Cost	Total Cost
PC	1311	82927661	1840	116349698
Bus	3034	13401178	4222	18648574
Truck	2899	109596695	4034	152505370
Two Wheeler	516	77013662	724	108053207

5.5 Vehicular Survey in Himachal Pradesh and Estimation of Air Pollution Abatement Cost of Vehicles

5.5.1 Vehicular Survey

Estimates of cost of air pollution abatement for different vehicles are also obtained using data collected through a primary survey of vehicles in Shimla. As explained in the earlier sections, data on distance traveled and fuel consumed per day by different vehicles used in preparing physical and monetary accounts of air pollution from the transport sector in HP are obtained from this survey. The survey of vehicles conducted in Shimla covers a sample of 700 vehicles pertaining to different vehicle categories, namely, buses, trucks, private cars, jeeps, taxicabs, two wheelers and other commercial vehicles. For all these vehicle categories, focus has been on HP registered vehicles. For instance, for the 'bus' category, the survey has been conducted for State Transport buses and HP registered tourist buses. Information has been obtained on the per day distance traveled by the vehicles, model and age of the vehicle, characteristic features such as size of the vehicle, type of fuel used, mileage, cost related information such as fuel cost, maintenance cost and insurance cost, and purchase and current price of the vehicle. Information has also been obtained on whether the vehicle has undergone any conversion in technology or if it is complying with any particular emission technology such as Pre Euro norm, Bharat Stage 2000 or Euro II.

5.5.2. Estimation of Hedonic Travel Cost Function

The hedonic travel cost function, which is a function of various characteristics of the vehicle: size of vehicle, distance traveled per day, and the emission coefficients are estimated for the passenger cars.

$$C = f\left(Size, Dist, EF\right)$$

where C: Total per day Cost to the owner of the vehicle

Size: Size of the vehicle. This variable takes a value of 1 for big vehicles and 0 otherwise.

Dist: Distance traveled per day by the vehicle

EF: Emission Factor or coefficient of the pollutant (CO_2, HC, NO_X, PM, as the case may be)

Variables in the Hedonic Cost Function:

Cost: This variable has been constructed using the annualized current price of the vehicle plus other costs like fuel cost, maintenance cost and insurance cost. The current price, which the private car owners stated, is the price, which they perceive to obtain if they sell the vehicle. This price has been annualized using the current bank-lending rate, which is 10.625% in the year 2003-04. The annualized cost thus obtained has been converted to per day cost.

Size: This is a dummy variable, which takes a value 1 for a big vehicle and 0 for a small vehicle.

Distance: Data on distance is expressed in kilometers traveled per day.

Emission coefficients: expressed in Kgs/Km.

Table 5.15 provides the descriptive statistics of variables used in the estimation.

Table 5.15: Descriptive Statistics of Variables

Variables	Mean	Std. Dev.
Cost (C)	163.63	82.47
Dist	28.89	19.67
CO2	0.00774	0.00509
HC	0.00089	0.00056
NOX	0.00092	0.00068
PM	0.00005	0.00001

Table 5.16: Correlation Matrix of Emission Variables

	CO2	NOX	HC	PM
CO2	1.00	0.93	0.99	0.88
NOX	0.93	1.00	0.97	0.99
HC	0.99	0.97	1.00	0.93
PM	0.88	0.99	0.93	1.00

The parametric estimates of hedonic travel cost function are given in Table 5.17. Separate estimates of cost function are made for three pollutants because correlation matrix of the emission factors as shown in Table 5.16 reveals very high pair-wise correlation coefficients, which are of the order of 0.8 and above. This implies that all the emission factors cannot be used as explanatory variables in the estimation of cost function because it would lead to biased estimates. Hence the cost variable has been regressed separately on each of the emission factors, with size and distance traveled per day as the other two explanatory variables. The standard diagnostic tests of heteroscedasticity have been performed on these models and the models are free from any such problem. Results indicate that the coefficients are highly significant (at the 1% level of significance) and have the expected signs.

Table 5.17: Parametric Estimates of Hedonic Travel Cost Function
Dependent Variable: Cost (C)

Variables (Expected Signs)	**Log-Log Model Coefficients (t-statistics)**		
	Reg. 1	**Reg. 2**	**Reg.3**
Constant	2.05** (7.546)	2.17** (8.306)	1.47** (4.208)
Size (+)	0.30** (3.956)	0.33** (4.244)	0.32** (4.139)
Dist (+)	0.48** (10.056)	0.51** (10.524)	0.49** (10.316)
CO2 (-)	-0.26** (-5.700)		
HC (-)			-0.26** (-5.828)
NOX (-)		-0.15** (-5.446)	
Uncentered R^2	0.62	0.61	0.62
Adjusted R^2	0.60	0.59	0.61

Note: ** denotes 1% level of significance, * denotes 5% level of significance

5.5.3 Estimates of Abatement Cost of Vehicular Pollution

Using the estimated hedonic cost functions, the annual abatement cost of vehicular pollution could be calculated for each of the pollutants namely, CO_2, NO_X, and HC. The derivative of cost function with respect to emissions gives us an estimate of increase in travel cost per day due to reduction of one kg of emissions per kilometer.

$$\frac{dC}{dCO2} = \frac{C}{CO2} * b = -0.264747 * 163.69/0.00774 = (-)5599.02$$

$$\frac{dC}{dHC} = \frac{C}{HC} * b = -0.260463 * 163.69/0.00085 = (-)50159.04$$

$$\frac{dC}{dNOX} = \frac{C}{NOX} * b = -0.151446 * 163.69/0.000922 = (-)26887.4$$

For instance the incremental cost for CO_2 is computed as Rs. 5599.02. Switching from pre Euro to Euro I vehicle technology requires an emission coefficient of 0.0013 kgs per kilometer for CO_2. Therefore the per day abatement cost of a small car is estimated as

Rs. 7.28 which makes the annual abatement cost equivalent to Rs. 2729.72. Table 5.18 provides similar estimates for NO_x, and HC. The data shows that there is a very high degree of correlation among emission variables as shown in Table 5.16 above implying that the switching of vehicles to emission reduction technologies results in the simultaneous reduction of all the emissions. Therefore the estimate of annual abatement cost for a passenger car is obtained as the maximum of the abatement cost estimates for CO_2 , NO_X, and HC given in Table 5.18.

Table 5.18: Estimates Annual Abatement Cost per Vehicle

PRIVATE CAR	Reduction of the Emission Kg/Km			Estimates of annual Abatement Cost		
	CO_2	HC	NO_x	CO_2	HC	NO_x
	(Due to change in Technology)			**Abatement cost per kg of emission**		
				5599.02	50159.04	26887.4
				Annual Abatement Cost (Rs./Veh)		
Pre euro 1996-00 to EUROI	0.0013	0.0002	0.0004	2729.72	4027.77	3974.63
Pre euro 1996-00 to EUROII	0.0015	0.0003	0.0005	3050.87	6224.74	5299.51
Pre euro 1996-00 to EUROIII	0.0025	0.0005	0.0006	5025.9	8879.4	5986.48
EUROI to EUROII	0.0002	0.0001	0.0001	321.144	2196.97	1324.88
E1UROI to EUROIII	0.0011	0.0003	0.0002	2296.18	4851.63	2011.85

Source: Estimated as explained in the text.

5.6 Conclusion

Air pollution from the road transport is non-point source of pollution as it is the case with water pollution from agriculture. In the absence of clearer methods in the literature on environmental pollution to measure the pollution loads and the cost of pollution abatement from the road transport, this paper outlines certain methods and provides case studies of road transport in AP and HP states in India. The suggested methods as shown in this paper require lot of data about the road transport. Vehicular transport creates demand for the waste disposal services from the atmosphere and there is a supply constraint on these services imposed by the environmental regulation in the form of emission norms (for example EURO norms as discussed in the paper). There is a problem of air pollution from the transport sector if the pollution load from vehicles exceeds the load corresponding to the emission norms. The cost of air pollution abatement is the cost to vehicles for complying with the emission norms.

Vehicular pollution could be reduced by changing the vehicular technologies and by improving the fuel quality. The Government of India has been recently introducing Euro norms, which are different for different vehicles. As explained in this paper the vehicular technologies and the fuel quality are different for different norms (EURO I, II, III, and IV). Estimates of air pollution loads in excess of loads compatible with norms for each type of vehicle are obtained. Estimates of pollution abatement cost for each type of vehicle in terms of cost of changing the vehicular technologies and the cost of using the improved fuels to comply with the emission norms are made. For example, the annual pollution abatement cost for a passenger car complying with EURO III norms is estimated as Rs. 7190 and Rs. 6624 respectively for AP and HP.

Table 5.19 shows the total abatement cost for complying with EURO II and EURO III emission norms for road transport sectors in AP and HP. The air pollution abatement cost for each type of vehicle is estimated as the sum of estimates of cost for the change in vehicular technology and improving the fuel quality.

Table 5.19: Monetary Accounts of Air Pollution Abatement in the Transport Sectors of AP and HP States (Rs. million)

	Andhra Pradesh		**Himachal Pradesh**	
Technology	**EURO II**	**EURO III**	**EURO II**	**EURO III**
1. Cost of upgrading Vehicular Technology	3617.295	25120.900	475.258	1752.737
2. Cost of Change in Fuel	5144.318	7188.641	282.939	395.557
3. Total Cost (1+2)	8761.613	32309.541	758.197	2148.294

Note:
It is to be noted that regarding the cost of technology upgradation, TERI provides estimates of investment costs of technology upgradation per vehicle for different vehicles from Euro I to Euro II and Euro III whereas the information on cost of fuel quality conversion is available for conversion from Pre Euro to Euro II and Euro III. This essentially implies that the total cost of abatement figures (for complying with Euro II and Euro III) at which the present study arrives by summing up the cost of technology upgradation and change in fuel quality, are in fact less than what it would have been, in case the conversion cost of upgrading vehicular technology was available for Pre Euro to Euro II and Pre Euro to Euro III.

The estimates of aggregate pollution abatement cost for the road transport in AP and HP are obtained by adding up costs for all the above vehicle categories. Estimates of air pollution abatement cost for the transport sector reported in Table 5.19 are made taking into account the number of vehicles on roads in the year 2001-2002 for AP and the year 2002-2003 for HP. The estimates of air pollution abatement cost of road transport required for complying with EURO III norms constitute 2.13 and 2.16 per cent of the State Domestic Product (SDP) respectively in AP and HP. Similar estimates for complying with EURO II norms are obtained as 0.578 and 0.76 per cent.

VI Industrial Water Pollution: Case Studies

6.1 A Method of Accounting

Environmental resources can ensure a sustainable supply of environmental services, waste disposal services, amenity benefits, and health benefits if they are preserved at their natural regenerative level. For example if the demand for waste receptive services by various economic activities is equal to the waste assimilative capacity of the environmental media, there is no pollution problem. Given that the demand for environmental services can exceed the natural sustainable levels of supply at a given time, and if measures are not taken to reduce this excess demand to zero then it is likely that there can be pollution problem or a degradation of environmental resources. The cost of reducing the demand for environmental services to the natural sustainable level of supply is regarded as the cost of sustainable use of environmental resources and in the case of industrial demand for environmental services it is the cost of sustainable industrial development. Estimation of this cost requires the development of physical and monetary accounts of environmental resources that are specific to industry.

A practical approach of developing accounts for the environmental pollution is to consider the pollution loads of industry with and with out environmental regulation and compare them with the pollution loads corresponding to the natural assimilative capacity of environmental media. As a part of environmental regulation, a firm faces a supply constraint on the waste disposal services in the form of prescribed standards for the effluent quality. The effluent standards are normally fixed such that if all the firms comply with them, the demand for the waste disposal services does not exceed the load corresponding to the natural sustainable level of supply. In a situation of no regulation, the pollution is measured as the difference between the pollution actually generated (influent load) and pollution that could be assimilated by the environmental media (load corresponding to the standards). In the case of regulation mandating the firms to comply with the pollution standards, there is no pollution problem if all the firms comply with the standards. However, there could be still a pollution problem, if some firms partially comply with the standards. There could be some firms having pollution loads exceeding the prescribed standards even after making some efforts to reduce pollution (effluent loads) and thus creating the pollution problem. Therefore physical accounts of pollution loads of the industry should present influent loads, effluent loads, and the loads corresponding to the assimilative capacity of environmental media or the prescribed standards.

The firm has to spend some of its resources to reduce the pollution loads to meet the effluent quality standards. The firm with a resource constraint will have lesser resources left for the production of its main product after meeting the standards. Therefore, the opportunity cost of meeting these standards is in the form of a reduced output of the firm. If all the firms in the industry meet the standards, the value of the reduced output of firms is the cost of sustainable industrial development. Alternatively, a firm has to manage resources from the alternative sources having an opportunity cost to reduce pollution. How to estimate this cost for a competitive firm facing the environmental regulation? It has to be estimated by studying the firm's behavior in making decisions regarding pollution loads and the choice of pollution abatement technologies. In some of the recent studies, the technology of a polluting firm is modeled on one of the two basic approaches using the conventional methods of the theory of production: (a) Considering effluent as an additional input in the production or profit function, and (b) By including abatement expenditures as an additional input in a cost function. In some studies, the pollution abatement technology is modeled with the assumption that it is non-separable from the technology of the main products while in others it is modeled with the assumption it is separable. In response to environmental regulation, firms may adopt different types of technologies to reduce pollution. Jorgenson and Wilcoxen (1990) identify three different responses of firms. First, the firm may substitute less polluting inputs for more polluting ones. Second, the firm may change the production process to reduce emissions. Third, the firm may invest in pollution-abatement devices. In practice, a firm may adopt a mix of these methods. The first two methods are non-separable with the production processes of main products while the third method is known as end-of-the pipe method.

There are a number of empirical studies beginning with the early eighties that examine the impact of environmental regulation on the economic performance of firms.[1] The ultimate aim of these studies has been to measure the effect of pollution regulation on total factor productivity growth (TFP). Most of these studies are based on production, cost or profit functions, with the pollution variable modeled indirectly using abatement expenditure as one of the inputs. The technology of water or air polluting firms could be described as one of joint production of good and bad outputs, the bad output being the pollution. The assumption of free disposal (a multi-product firm can produce more of one output without reducing the outputs of other goods) that is normally made in the conventional production theory cannot be applied to describe the technologies of polluting firms. Shephard (1974, p.205) noted that

> ***"...for the future where unwanted outputs of technology are not likely to be freely disposable, it is inadvisable to enforce free disposal of inputs and outputs. Since the production function is a technological statement, all outputs, whether economic goods are wanted or not, should be spanned by the output vector y".***

Also, the conventional studies have implicitly assumed that the firms are operating on the production frontier and that pollution control does not have an impact on production efficiency. However, many recent studies have shown that these assumptions are unlikely to hold in many cases.[2] Finally, the profit or cost functions used to represent production technology require firm-specific prices, especially input prices,[3] the reliable data of which is difficult to obtain. As it is already described in chapter III, the distance function methodology potentially avoids some of these problems[4].

Monetary accounts of industrial pollution could be obtained using the estimates of physical accounts of pollution and the shadow prices of pollutants. Murty and surrender

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[1] See Myers and Nakamura, 1980; Pittman, 1981, 1983; Gollop and Roberts, 1983; Conrad and Morrison, 1989; Jorgenson and Wilcoxen, 1990; Barbara and McConnell, 1990, and Gray and Shadbegian, 1993, 1995.

[2] See Fare et al. 1989; Fare et al. 1993; Hakuni, 1994; Yaisawarng and Klien, 1994;Porter and van der Linde, 1995; Coggin and Swinton, 1996, and Surender Kumar 1999.

[3] See recent studies on pollution abatement cost functions in India. For example, Mehta et al. 1995; James & Murty 1998; Pandey, 1998, and Smita Misra, 1999.

[4] See Murty and Surender Kumar (2004) for more details.

Kumar (2002; 2004) have estimated the shadow prices of pollutants for the Indian water polluting industries using the methodology of output distance function. Table 6.1 provides estimates of shadow prices of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Suspended Solids (SS) for the water polluting industry in India. These estimates are used in Sections 6.3 and 6.4 for estimating firm specific and industry specific monetary accounts of water pollution for the Indian manufacturing industry.

Table 6.1: Estimates of Shadow Prices of Water Pollution for Indian Industries (Rs. million per ton)

Industry/ Pollutant	BOD	COD	SS
Leather	0.0107	0.0636	0.0217
Distillery	0.0187	0.0451	0.0270
Chemicals	0.0112	0.0522	0.0131
Sugar	0.0123	0.0558	0.0168
Paper & Pulp Products	0.0185	0.0292	0.0184
Fertilizer	0.0106	0.0558	0.0011
Pharmaceuticals	0.0093	0.0638	0.0207
Petro-Chemicals	0.0136	0.0417	0.0125
Miscellaneous	0.0134	0.0593	0.012
Over All	0.0134	0.0506	0.0167

Source: Murty and Surendar Kumar (2004)

6.2 Generalized Firm Production Account

Production accounts of manufacturing firms could be generalized by providing environmental related information of production. The firm specific physical and monetary accounts of pollution could be used to estimate the cost of pollution abatement incurred by the firm or the abatement cost it has to incur if it has to comply with the environmental regulation. Also they could be used to make estimates of potential damages the pollution causes to the public. Case studies of some water polluting firms from AP and HP are presented below to highlight a method of providing the generalized production accounts. Detailed micro case studies of Sirpur Paper and Pulp Mill from AP and Bhandari Deepak Industries Ltd. of HP are done for this purpose.

Tables 6.2 to 6.5 provide the production account and physical and monetary accounts of water pollution for a big paper mill (Sirpur Paper and Pulp Mill) in AP. Similar information is provided in Tables 6.6 to 6.9 for a small paper mill (Bhandari Deepak Industries Ltd) in HP. We have collected data for six years, data for the three years1996-99 for an earlier study[5] and the data for recent three years 2001-2004 for the current study about the paper mill in AP and for only three years 2001-2004 for the mill in HP. As expected, the conventional production accounts of both the mills did not give any information about the pollution abatement or environmental management. However, both the mills have reported as evident from Tables 6.3 and 6.7 that they are complying with the prescribed water pollution standards. Satellite accounts providing environment related information and supplementing the main production account of a polluting firm have to be developed as empirical micro foundations of Green Accounting. These accounts as

Table 6.2: Production Accounts of Sirpur Paper & Pulp Mill of Andhra Pradesh

	1996-97	1997-98	1998-99	2001-02	2002-03	2003-04
Out Put (tones)	57360	58457	57334	60921	77974	79170
Turnover (Rs. Million)	1593.00	1576.00	1449.00	1761.50	2311.10	2487.80
Fixed Capital	3673.00	3769.38	3868.29	3969.80	4038.40	4181.20
Wage Bill	218.30	244.50	250.80	318.60	367.40	372.80
Water Consumed	2.00	1.96	1.85	32.20	38.00	40.90
Fuels consumed	457.80	409.75	388.73	408.13	514.33	508.43
Materials consumed	411.00	345.70	319.60	641.30	851.80	968.80
Gross value added	722.20	818.60	738.82	810.70	1037.80	1100.50
Depreciation	183.65	188.47	193.41	198.49	201.92	209.06
Net value added	538.55	630.13	545.41	612.21	835.88	891.44
Net return on capital	0.09	0.10	0.08	0.07	0.12	0.12
Annual Production Cost	1089.10	1001.91	960.98	1400.23	1771.53	1890.93
Production Cost for Ton (Rs.)	18987.06	17139.18	16761.01	22984.29	22719.44	23884.38
Primary Input Cost for Ton (Rs.)	12590.69	14003.37	12886.32	13307.40	13309.56	13900.47
Gross rate of return	0.14	0.15	0.13	0.12	0.17	0.17

[5] Murty and Surender Kumar (2004).

Table 6.3: Water Pollution Concentrations of Sirpur Paper and Pulp Mill

	1996-97	1997-98	1998-99	2001-02	2002-03	2003-04
Avg. Vol. of untreated waste water (ltr /day)	37557000	36892000	36892000	40100000	39460000	38200000
Daily waste handling capacity of Effluent Treatment of the Plant (ltrs)	45460000	45460000	45460000	45460000	45460000	45460000
Influent BOD (mg/ltr)	250	265	260	275	260	280
COD (mg/ltr)	850	910	850	770	630	800
PH	8.4	8.5	8.4	8.45	8.3	8.4
SS (mg/ltr)	970	890	870	610	725	730
DS (mg/ltr)				1530	1610	1780
Effluent BOD (mg/ltr)	29	28	25	28	28.5	28
COD (mg/ltr)	240	225	240	245	240	245
PH	7.2	7.1	7.3	7.25	7.3	7.2
SS (mg/ltr)	95	95	95	96	94	95
DS (mg/ltr)	NA	NA	NA	1250	1350	1580

Table 6.4: Physical Accounts of Water Pollution of Sirpur Paper & Pulp Mill

Influent Load (Ton/Year	**BOD**	**COD**	**SS**
1996-97	3427.08	11652.06	13297.06
1997-98	3568.38	12253.68	13061.61
1998-99	3501.05	11445.74	11715.05
2001-02	4025.04	11270.11	8928.27
2002-03	3744.75	9073.83	10442.10
2003-04	3904.04	11154.40	10178.39
Effluent Load (Ton/year)	**BOD**	**COD**	**SS**
1996-97	397.54	3289.99	1302.29
1997-98	377.04	3029.76	1279.23
1998-99	336.64	3231.74	1265.76
2001-02	409.82	3585.94	1405.10
2002-03	410.48	3456.70	1353.87
2003-04	390.40	3416.04	1324.59
Load as per Std (Ton/year)	**BOD**	**COD**	**SS**
1996-97	411.25	3427.08	1370.83
1997-98	403.97	3366.40	1346.56
1998-99	403.97	3366.40	1346.56
2001-02	439.10	3659.13	1463.65
2002-03	432.09	3600.73	1440.29
2003-04	418.29	3485.75	1394.30
Load reduction (inf-eff)	**BOD**	**COD**	**SS**
1996-97	3029.54	8362.07	11994.77

1997-98	3191.34	9223.92	11782.38
1998-99	3164.41	8214.00	10449.29
2001-02	3615.22	7684.16	7523.16
2002-03	3334.27	5617.13	9088.23
2003-04	3513.64	7738.37	8853.81
Load yet to be reduced (eff-std.)	**BOD**	**COD**	**SS**
1996-97	-13.71	-137.08	-68.54
1997-98	-26.93	-336.64	-67.33
1998-99	-67.33	-134.66	-80.79
2001-02	-29.27	-73.18	-58.55
2002-03	-21.60	-144.03	-86.42
2003-04	-27.89	-69.72	-69.71

Note: The negative values for the load yet to be reduced indicate that there is over compliance to the pollution standards by the mill

Table 6.5: Monetary Accounts of Water Pollution of Sirpur Paper & Pulp Mill

	BOD	COD	SS	Total Abatement Exp. (Rs. Million)	Abatement Exp. / Ton (Rs.)	Share of Abatement Exp. In Turnover
Abatement expenditure incurred (inf-eff)*SP	**Million Rs.**					
1996-97	55.95	244.04	221.05	521.04	9083.68	32.71
1997-98	58.94	269.19	217.14	545.27	9327.71	34.60
1998-99	58.44	239.72	192.57	490.73	8559.14	33.87
2001-02	66.77	224.25	138.64	429.66	7052.74	24.39
2002-03	61.58	163.93	167.48	392.99	5040.01	17.00
2003-04	64.89	225.83	163.16	453.88	5732.98	18.24

Table 6.6: Production Accounts of Bhandari Deepak Industries Ltd. of HP

	2001-02	2002-03	2003-04
Out Put (tons)	4658.93	5118.79	6049.57
Turnover (Rs. Million)	69.51	70.51	86.11
Fixed Capital	46.45	48.05	54.17
Wage Bill	2.31	1.98	1.63
Water Consumed	0.00	0.00	0.00
Fuels consumed	16.87	15.52	17.66
Materials consumed	34.89	33.38	42.97
Gross value added	17.75	21.61	25.48
Depreciation	2.346	2.478	2.657
Net value added	15.41	19.13	22.82
Net return on capital	0.28	0.36	0.39
Annual Production Cost	54.07	50.88	62.26
Production Cost for Ton (Rs.)	11606.09	9939.66	10291.97
Primary Input Cost for Ton (Rs.)	3810.31	4221.51	4211.21
Gross rate of return	0.33	0.41	0.44

Table 6.7: Water Pollution Concentrations of Bhandari Deepak Industries Ltd. of HP

	2001-02	2002-03	2003-04
Avg. Vol. of untreated wastewater (ltr/day)	500000	1000000	1000000
Daily waste handling capacity of Effluent Treatment of the Plant (ltrs)	1000000	1200000	1200000
Influent			
BOD (mg/ltr)	1200	1200	1200
COD (mg/ltr)	3600	4000	4000
PH	8.75	8.75	8.75
SS (mg/ltr)	550	550	550
DS (mg/ltr)	1750	1750	1750
Effluent			
BOD (mg/ltr)	100	80	80
COD (mg/ltr)	375	325	325
PH	8.25	8.25	8.25
SS (mg/ltr)	120	120	120
DS (mg/ltr)	1000	1000	1000

Table 6.8: Physical Accounts of Water Pollution of Bhandari Deepak Industries Ltd. of HP

Influent Load (Ton/Year	**BOD**	**COD**	**SS**
2001-02	219.00	657.00	100.38
2002-03	240.90	803.00	110.41
2003-04	284.70	949.00	130.49
Effluent Load (Ton/year)	**BOD**	**COD**	**SS**
2001-02	18.25	68.44	23.73
2002-03	20.08	65.24	26.10
2003-04	23.73	77.11	30.84
Load as per Std (Ton/year)	**BOD**	**COD**	**SS**
2001-02	5.48	45.63	18.25
2002-03	6.02	50.19	20.08
2003-04	7.12	59.31	23.73
Load reduction (inf-eff)	**BOD**	**COD**	**SS**

2001-02	200.75	588.56	76.65
2002-03	220.83	737.76	84.32
2003-04	260.98	871.89	99.65
Load yet to be reduced (eff-std.)	**BOD**	**COD**	**SS**
2001-02	12.78	22.81	5.48
2002-03	14.05	15.06	6.02
2003-04	16.61	17.79	7.12
	BOD	COD	SS
Abatement expenditure incurred (inf-eff)*SP	**Rs.**		
2001-02	3707651.75	17176608.00	1412582.85
2002-03	4078416.93	21530678.40	1553841.14
2003-04	4819947.28	25445347.20	1836357.71

Table 6.9: Monetary Accounts of Water Pollution of Bhandari Deepak Industries Ltd. of HP

	BOD	**COD**	**SS**	**Total Abatement Exp. (Rs. Million)**	**Abatement Exp. / Ton (Rs.)**	**Share of Abatement Exp. In Turnover**
Abatement expenditure incurred (inf-eff)*SP	**Million Rs.**					
2001-02	3.7077	17.1766	1.4126	23.2994	5001.03	33.52
2002-03	4.0784	21.5307	1.5538	27.9729	5464.74	39.67
2003-04	4.8199	25.4453	1.8364	33.0588	5464.66	38.39
Abatement expenditure yet to be incurred to comply with std (eff-std.)*SP	**BOD**	**COD**	**SS**			
2001-02	0.2359	0.6658	0.1009			
2002-03	0.2595	0.4394	0.1110			
2003-04	0.3067	0.5193	0.1312			

described in Tables for a mill in AP and in Tables for a mill in HP provide physical and monetary accounts of water pollution describing pollution loads and the cost of pollution abatement. Since both the firms are complying with the safe water pollution standards (MINAS source specific standards in India), the cost of water pollution abatement is implicitly accounted in their production accounts and it gets reflected in the estimation of value added of each firm. However, if a polluting firm is not complying with the standards, the hypothetical cost of pollution abatement for meeting the standards has to be deducted from a conventional measure of net value added by the firm to estimate the environmentally corrected net value added.

The cost of water pollution abatement for both the firms described in Tables 6.5 and 6.9 is estimated using the estimates of marginal cost of abatement or shadow prices of pollutants for the Indian water polluting industry given in an earlier study (Murty and Kumar, 2004). Estimates of cost of abatement for three important water pollutants: BOD, COD, and SS are obtained. The methodology used for estimating the shadow prices of pollutants considers that these cost are additive[6]. The estimates for the recent year 2003-2004 show that the cost of complying with the MINAS standards of water pollution in India forms 18.24 percent and 38.39 percent of turnover respectively for the mill in AP and the mill in HP. However, if one makes the assumption that there could be the multicollinearity between pollutants and the reduction of one pollutant means the reduction of all, the cost water pollution abatement for the firm may be taken as the maximum among the costs of abatement of three pollutants. As we could see from Tables, COD has the maximum per ton cost of abatement or the cost of abatement incurred by the firms. During the year 2003-2004, the cost of abatement of COD is estimated as Rs. 225.83 million for the mill in AP and Rs. 25.96 million for the mill in HP. If you take the cost of abatement of COD as the total abatement cost of the mill, the abatement cost constitutes 9 and 30.15 percent of turnover respectively for the mill in AP and the mill in HP.

6.3 Industry Accounts

Aggregate production accounts as given by the data from the Annual Survey of Industries published by CSO and the satellite accounts water of pollution for the major water polluting in AP and HP are presented in this Section. Tables 6.10-6.13 provide these tables for the paper and pulp industry in the two states while Appendix A6 provide tables

[6] The methodology of output distance function used in Murty and Kumar (2004) and in Chapter III of this report consider that the pollutants are bad outputs jointly produced with the good outputs by the polluting firms.

for other water polluting industries. The influents loads of major water pollutants are very high for all the industries, times for BOD, times for COD and times for SS to the load corresponding to MINAS standards in the case of paper and pulp industry in AP. Similar estimates could be found for the other major water polluting industries in AP and HP. The cost of reducing the pollution loads to the safe levels is also prohibitively high for these industries. Tables 6.14-6.17 provide aggregate production accounts and the satellite accounts of pollution for the water polluting industries in AP and HP.

Table 6.10: Production Account of Paper and Pulp industry in Andhra Pradesh

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	265	317
2	Factories in operation	223	293
3	Fixed Capital	15712.4	16804.5
4	Physical working capital	2494	2570.7
5	Invested capital	18206.5	19375.2
6	Gross value of addition to fixed cap	8320.4	1278.6
7	Rent paid for fixed assets	65.1	56
8	Outstanding loan	7632.7	5266.3
9	Interest paid	1269.7	1251.6
10	Gross value of plant and machinery	15680.2	18850
11	Value of prod and by-prod	11121.7	16574.2
12	Total o/p	11922.8	17245.4
13	Fuels consumed	2098.8	2364.5
14	Materials consumed	5824.4	8942.6
15	Total I/p	8883.6	12364.6
16	Gross value added	3039.2	4880.8
17	Depreciation	756	1030.6
18	Net value added	2283.2	3850.2

Table 6.11: Physical and Monetary Accounts of Pollutants of Paper and Pulp in Andhra Pradesh

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	*Influent Load (Tons)*	44303.01	162272.1	23522.4	66022.9	241827.2	35054.44
2	*Load as per std.*	1452.448	12103.74	4841.494	2164.522	18037.69	7215.074
3	*Load to be reduced (1-2)*	42850.56	150168.3	18680.91	63858.38	223789.5	27839.37
Monetary Accounts							
4	*Cost of meeting std. (1-2)*SP*	791.4241	4382.468	344.2629	1179.426	6531.007	513.0405

Table 6.12: Generalised Production Account of Paper and Pulp industry in Himachal Pradesh

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	11.00	23.00
2	Factories in operation	11.00	22.00
3	Fixed Capital	319.30	589.60
4	Physical working capital	174.20	173.30
5	Invested capital	493.50	762.90
6	Gross value of addition to fixed cap	52.40	54.50
7	Rent paid for fixed assets	36.40	35.40
8	Outstanding loan	17.70	921.80
9	Interest paid	21.50	124.10
10	Gross value of plant and machinery	292.00	1157.10
11	Value of prod and by-prod	482.80	1227.20
12	Total o/p	485.30	1233.10
13	Fuels consumed	113.90	186.50
14	Materials consumed	268.80	788.00
15	Total I/p	417.70	1019.60
16	Gross value added	67.60	213.50
17	Depreciation	20.90	88.70
18	Net value added	46.70	124.80

Table 6.13: Generalised Physical and Monetary Accounts of Pollutants of Paper and Pulp in Himachal Pradesh

		1998-99			2000-01		
Phy. Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	1923.22	7044.33	1021.12	4888.52	17905.56	2595.53
2	Load as per std.	63.05	525.43	210.17	160.27	1335.56	534.22
3	Load to be reduced (1-2)	1860.17	6518.90	810.95	4728.25	16570.00	2061.30
Mon. Accounts							
4	Cost of meeting standards (1-2)*SP	34.36	190.25	14.94	87.33	483.57	37.99

Table 6.14: Aggregate Production Accounts of Water Polluting Industries in AP

	(Value in million, others in numbers)		
S. No.	**Characteristic**	**1998-99**	**200-01**
1	No. of factories	6529	6978
2	Factories in operation	5822	6381
3	Fixed Capital	161599.1	158392.3
4	Physical working capital	56958.8	79968.4
5	Invested capital	218558.1	238360.7
6	Gross value of addition to fixed cap	23568	16338.1
7	Rent paid for fixed assets	3523.4	1066.2
8	Outstanding loan	99514.6	111383.1
9	Interest paid	16188.3	13969.2
10	Gross value of plant and machinery	165371.3	172920.2
11	Value of prod and by-prod	261210.8	321182.6
12	Total o/p	290916.2	380979.9
13	Fuels consumed	16854.5	15258.3
14	Materials consumed	168455.6	270752.8
15	Total I/p	244311.6	329459.7
16	Gross value added	46604.9	51520.2
17	Depreciation	17999.7	15267.1
18	Net value added	35398.7	38567.1

Table 6.15: Aggregate Physical and Monetary Accounts of Water Polluting Industries in AP

Physical Accounts		**1998-99**			**2000-01**		
		BOD	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	6450011	24688003	19697045	6568612	25407587	20582620
2	Effluent Load	817592.7	3571510	1327230	830862.2	3621787	1349575
3	Load as per std.	688100.1	5734168	2293667	700649.9	5838749	2335499
Monetary Accounts							
4	Cost to be incurred to	77082.28	1003818	238270	78203.27	1034950.73	251383.51
	Complying to std. (1-3)* SP						

Table 6.16: Aggregate Production Accounts of Water Polluting Industries in HP

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	120	141
2	Factories in operation	115	137
3	Fixed Capital	3918	6845.2
4	Physical working capital	2144.4	3908.4
5	Invested capital	6972.7	10753
6	Gross value of addition to fixed cap	2618.2	583.1
7	Rent paid for fixed assets	153.2	65
8	Outstanding loan	2936.6	5193.3
9	Interest paid	516.1	946.2
10	Gross value of plant and machinery	4493.5	6095.5
11	Value of prod and by-prod	7532.7	18411
12	Total o/p	7841	18934
13	Fuels consumed	336.7	506.1
14	Materials consumed	5268.8	12931
15	Total I/p	6083.8	14582
16	Gross value added	1757.3	4352
17	Depreciation	236.7	449.2
18	Net value added	152.6	3902.8

Table 6.17: Aggregate Physical and Monetary Accounts of Water Polluting Industries in HP

		1998-99				2000-01	
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	2891381.29	7468331.05	1914700.60	12039211.41	29460899.05	4766846.75
2	Effluent Load	148966.52	917912.67	185581.22	523168.28	3517478.07	589942.33
3	Load as per std.	58345.19	486209.99	194484.00	131198.57	1093321.53	437328.61
Monetary Accounts							
4	Cost to be incurred to						
	comply to std. (1-3)* SP	50596.08	326322.42	29671.55	217864.01	1301803.92	86782.43

6.4 Conclusion

Firm level production and environmental (pollution) accounts of industries become micro empirical foundations for developing aggregate environmental and economic accounts for the industry. Firm production accounts could be generalized as shown in this chapter to make estimates of environmentally corrected value added by the firms. The data from the generalized production accounts of the firms for a given industry could be used to estimate shadow prices or the marginal cost of pollution abatement as done in Chapter III for air pollution by thermal power generation and in Murty and Surender Kumar (2004) for industrial water pollution. These shadow prices in combination with the physical accounts of pollution explaining contribution of each firm's contribution to the pollution loads could be used to estimate the monetary accounts of pollution by a firm.

A methodological approach for the environmental resource accounting of the industry implicit in the theoretical model presented in Chapter II requires the estimation of changes in stocks of pollution as a result of industrial pollution and the monetary valuation of these stocks at the marginal cost of pollution abatement. Estimation of each firm's contribution to the changes in stocks of pollution is made with the understanding that the pollution load from a firm in excess of load corresponding to the prescribed standards (MINAS standards) adds to a change in stock of pollution in the environmental media. As explained in Section 1 of this chapter, if all firms comply with the pollution standards there will not be any pollution problem. The same method is used to estimate the changes in stocks of pollution for each industry and for all the water polluting industries in AP and HP.

Estimates of monetary values of changes in the stocks of pollution at the firm, industry and the aggregate manufacturing level could be used to estimate the environmentally corrected net value added at level. The general accounting principle explained in Chapter II requires that the value of changes in stock of pollution measured at the marginal cost of abatement or shadow price has to be deducted from the net value added in the conventional production accounts for measuring the environmentally corrected net value added. Case studies of two firms from paper and pulp industry (one from AP and another from HP) describe the firm level environmental and economic accounting.

VII Source Specific Accounts of Production and Water Pollution Loads for Agricultural Sector in AP and HP

7.1 Introduction

Modern agricultural technology, which was introduced in the mid sixties in India, is one of the key factors to increase agricultural production. Modernization of agriculture involved adoption of crop production technology such as use of HYV seeds, chemical fertilizers, insecticides, weedicides, irrigation water, etc. and also multiple cropping system and expansion of area under cultivation. Although the development of modern agricultural technology has increased food production and basic material for agro-industries, it has put forth the question, as to whether this modernization in agriculture is eco-friendly for sustainable agricultural development.

A continuous growth in the modern agriculture has put enormous pressure on natural resources such as land and water. Particularly, excessive application and misutilisation of inputs like water, chemical fertilizers, insecticides and weedicides, have caused water pollution, deterioration of soil health, and water logging. Over a period of 25 years, i.e. from the seventies up till mid nineties, the rate of increase in the consumption of chemical fertilizers (N, P, K) was very high of the order of 0.47 million tons per year. The total consumption of fertilizers increased by about seven times during the period. As regards pesticides, consumption figures rose from 24.3 thousand tons in 1970-71 to 75 thousand tons in 1990-91 and later although the growth rate in consumption slowed down, it came down to 61.26 thousand tons in 1995-96. This was because, of late, pesticides have been used with care, mainly in crops like cotton and vegetables.

In an attempt to develop physical and monetary accounts of pollution as satellite accounts to the conventional production accounts of agriculture, it is important to find out the relationship between the use of fertilizer and pesticides and the quality of soil, and surface and ground water. Generalized farm production accounts with additional information about the environmental effects of farm production activities form the database for developing the satellite accounts.

7.2 An Approach for Accounting Water Pollution Loads In Agriculture

Water pollution from the use of fertilizers, pesticides, and excessive irrigation in agriculture is a non-point source of pollution. Unlike industrial pollution dealt with in chapters 3, 4, and 6, it is difficult to relate the pollution from agricultural sources to the ambient quality of surface and ground water resources. It could be therefore difficult to fix the source specific standards for the run off from the farms so that if the farms comply with these standards, the ambient standards of water quality could be met. We could generalize farm production accounts by additionally providing the physical accounts of water pollution loads from the farms but in the absence of farm specific standards for water pollution, it is not possible to estimate the change in pollution load attributable to the farm.

Soil and water act as sinks for fertilizers and pesticides used in Agriculture. After their application, their residues are washed down to the soil and from there reach aquatic bodies by run-off and leaching. Their continuance in soil, plant and aquatic environment is a cause of concern for the environment management. Farm surveys collecting the samples of soils and farm run-off under different crops and laboratory analysis of it could provide data relating the pollution loads with fertilizer and pesticide use at a farm level.

The excessive use of fertilizers has an adverse effect on soil and water as well as environment. It has been reported by several researchers that because of high level of fertilizer application, soil health has deteriorated slowly (Singh et al. 1995). The physical, chemical and biological properties of soil are adversely affected by long-term continuous use of high doses of inorganic fertilizers. The long-term effect of increasing the nitrogenous fertilizer usage is the accumulation of nitrates in the soil. Similarly, sulphatic fertilizers leave sulphates in the soil. Due to rainfall or excessive use of irrigation water, these chemicals may change the alkaline or acidic nature of the soil. The nitrates flow into surface and ground water bodies (rivers, wells, lakes and tanks), and hence it is obvious that there is also a leakage in the drainage system, which goes in the drinking water. Apart from this, greater use of nitrogen in the form of ammonium sulphate in the rice crop emanates the ammonia, which goes into the atmosphere. Also, some of the heavy metals, which are present in the fertilizers, are also leached. The analysis of data about soil quality, and quality of surface run-off and ground water for a large sample of farms from different agro-climatic regions and different crops could provide information for estimating the pollution load at the farm level.

The generalized farm accounts data with the information on pollution loads at farm level constitute the empirical micro foundations for developing satellite accounts of pollution from the agricultural sector. It is important to find out the empirical relationship between the pollution loads at sources and the ambient water or air pollution. General appendices A1, A2, and A3 provide data on ambient surface water quality, ground water quality, and air quality in AP and HP states. It is useful for designing environmental policy instruments to know about the contributions of different sectors: industry, agriculture, and households to the ambient environmental quality.

7.3 Farm Production Accounts and Pollution Loads

Farm production accounts or cost of cultivation data from the publications of Commission on Agricultural Costs and Prices, Government of India describes production and input costs for different crops in different states in India. Data on use of fertilizers and pesticides per hectare, the main cause of concern for the pollution from agriculture, for different crops are given in these accounts. As explained in Section 7.2, using the data on fertilizer and pesticide consumption and the data from the farm surveys on the percentages of fertilizers and pesticides used in the cultivation retained in the soil, surface run-off and ground water, one could estimate the pollution loads from agriculture.

For example, a study by Deb and Joshi (1994) report about the metal contents of a kilogram of N P K fertilizers used in agriculture as given in Table 7.1. Tables 7.2- 7.6 provide data of farm production and cost accounts for different crops in AP. These tables report fertilizer consumption per hectare for each crop. The fertilizer consumption varies from 259.37 kgs per hectare for sugarcane to 69.87 kgs per hectare for groundnut. Satellite pollution accounts for each crop explaining the metals as residues generated from the fertilizer use are prepared as reported in Tables 7.2-7.6.

Table 7.1: Metal content in per kg. of N,P, K fertilizers

Source	Metals (mg/kg)				
	Cadmium	Chromium	Copper	Lead	Zinc
NPK fertilizers (8-10-18)	4.9	54.3	8.3	3.2	97.5

Source: Deb and Joshi (1994)

7.2 Farm Production Accounts and Pollution Loads for Paddy in Andhra Pradesh for the year 1999-00

Paddy	
Area (Lakh hectares)	39.04
Value of main product per hectare (Rs.)	25232.4
Yield per hectare (qntl)	46.75
Value of by product per hectare (Rs.)	1538.45
Cost of Cultivation (Rs./hectare):	
I. Operational Cost	*16195.03*
Human Labour	8553.66
Bullock Labour	555.32
Machine labour	1494.13
Seed	819.39
Fertilizer	2116.94
Manure	452.89
Insecticide	793.2
Irrigation Charges	997.73
Interest on Working Capital	406.62
Miscellaneous	5.15
II. Fixed Cost	***9130.26***
Rental value of owned land	7904.46
Rent paid for leased in land	160.36
Land rev., cesses, taxes	21.42
Depreciation on implements and farm buildings	181.22
Interest on fixed capital	862.8
Total (I+II)	**25325.29**
III. Inputs per hectare	
Seeds (kgs)	85.74
Fertilizers (Kgs)	178.63
Manure (qntls)	22.83
Human labour (man-hrs)	1007.42
Animal Labour (pair-hours)	40.77

IV. Physical Accounts of Pollution (Metal Content in Fertilizer) Units: mg /hectare				
Cadmium	Chromium	Copper	Lead	Zinc
875.287	9699.609	1482.629	571.616	17416.43

7.3 Farm Production Accounts and Pollution Loads for Jowar in Andhra Pradesh for the year 1999-00

Jowar	
Area (Lakh hectares)	7.67
Value of main product per hectare (Rs.)	6902.02
Yield per hectare (qntl)	10.26
Value of by product per hectare (Rs.)	1002.36
Cost of Cultivation (Rs./hectare):	
I. Operational Cost	*5514.29*
Human Labour	2665.88
Bullock Labour	1211.69
Machine labour	266.72
Seed	169.7
Fertilizer	918.56
Manure	122.5
Insecticide	16.7
Irrigation Charges	10.31
Interest on Working Capital	132.2
Miscellaneous	
II. Fixed Cost	***3784.72***
Rental value of owned land	2181.81
Rent paid for leased in land	213.65
Land rev, cesses, taxes	5.01
Depreciation on implements and farm buildings	316.21
Interest on fixed capital	1068.04
Total (I+II)	**9299**
III. Inputs per hectare	
Seeds (kgs)	10.84
Fertilizers (Kgs)	77.46
Manure (qntls)	4.95
Human labour (man-hrs)	431.39
Animal Labour (pair-hours)	100.58

IV. Physical Accounts of Pollution (Metal Content in Fertilizer) Units: mg				
Cadmium	Chromium	Copper	Lead	Zinc
379.554	4206.078	642.918	247.872	7552.35

7.4 Farm Production Accounts and Pollution Loads for Maize in Andhra Pradesh for the year 1999-00

Maize	
Area (Lakh hectares)	4.39
Value of main product per hectare (Rs.)	9547
Yield per hectare (qntl)	21.42
Value of by product per hectare (Rs.)	1090
Cost of Cultivation (Rs./hectare):	
I. Operational Cost	***7827.74***
Human Labour	3395.46
Bullock Labour	928.27
Machine labour	459.58
Seed	584.32
Fertilizer	1662.72
Manure	243.21
Insecticide	118.82
Irrigation Charges	248.36
Interest on Working Capital	187
Miscellaneous	
II. Fixed Cost	***472.3***
Rental value of owned land	3179.28
Rent paid for leased in land	20.11
Land rev., cesses, taxes	5.27
Depreciation on implements and farm buildings	338.14
Interest on fixed capital	1179.2
Total (I+II)	**12550.04**
III. Inputs per hectare	
Seeds (kgs)	20.44
Fertilizers (Kgs)	143.97
Manure (qntls)	11.25
Human labour (man-hrs)	519
Animal Labour (pair-hours)	62.55

IV. Physical Accounts of Pollution

(Metal Content in Fertilizer) Units:mg

Cadmium	Chromium	Copper	Lead	Zinc
705.453	7817.571	1194.951	460.704	14037.08

7.5 Farm Production Accounts and Pollution Loads for Groundnut in Andhra Pradesh for the year 1999-00

Groundnut	
Area (Lakh hectares)	17.93
Value of main product per hectare (Rs.)	9549.9
Yield per hectare (qntl)	8
Value of by product per hectare (Rs.)	717.12
Cost of Cultivation (Rs./hectare):	
I. Operational Cost	***10214.2***
Human Labour	4705.8
Bullock Labour	954
Machine labour	387.29
Seed	2349.2
Fertilizer	960.36
Manure	221.32
Insecticide	118.84
Irrigation Charges	210.41
Interest on Working Capital	234.43
Miscellaneous	2.6
II. Fixed Cost	***4374.71***
Rental value of owned land	2905.99
Rent paid for leased in land	90.22
Land rev., cesses, taxes	10.28
Depreciation on implements and farm buildings	336.5
Interest on fixed capital	1031.7
Total (I+II)	**14589**
III. Inputs per hectare	
Seeds (kgs)	98.86
Fertilizers (Kgs)	69.87
Manure (qntls)	9.14
Human labour (man-hrs)	651.6
Animal Labour (pair-hours)	70.4

IV. Physical Accounts of Pollution (Metal Content in Fertilizer) Units:mg				
Cadmium	Chromium	Copper	Lead	Zinc
342.363	3793.941	579.921	223.584	6812.325

7.6 Farm Production Accounts and Pollution Loads for Sugarcane in Andhra Pradesh for the year 1999-00

Sugarcane	
Area (Lakh hectares)	2.31
Value of main product per hectare (Rs.)	52431.66
Yield per hectare (qntl)	728.37
Value of by product per hectare (Rs.)	622.56
Cost of Cultivation (Rs./hectare):	
I. Operational Cost	***29815.2***
Human Labour	16459.63
Bullock Labour	529.84
Machine labour	1150.4
Seed	4253.44
Fertilizer	2867.05
Manure	210.37
Insecticide	701.68
Irrigation Charges	2090.37
Interest on Working Capital	1552.34
Miscellaneous	
II. Fixed Cost	***17617.1***
Rental value of owned land	13691.8
Rent paid for leased in land	1941.26
Land rev., cesses, taxes	11.71
Depreciation on implements and farm buildings	373.9
Interest on fixed capital	1598.41
Total (I+II)	**47432.33**
III. Inputs per hectare	
Seeds (qntls)	53.04
Fertilizers (Kgs)	259.37
Manure (qntls)	14.91
Human labour (man-hrs)	2176.33
Animal Labour (pair-hours)	38.08

IV. Physical Accounts of Pollution (Metal Content in Fertilizer) Units:mg				
Cadmium	Chromium	Copper	Lead	Zinc
1270.913	14083.791	2152.771	829.984	25288.58

7.4 Fertilizer and Pesticides Use in Agriculture and Pollution Loads in AP and HP

Tables 7.7 and 7.8 provide year-wise consumption of fertilizers during 1996-97 to 2001-02. Particularly, for the states of Andhra Pradesh and Himachal Pradesh, season wise consumption of fertilizers is given below. The district-wise consumption of N, P, K fertilizers is given in the appendix.

Table 7.7: Yearly consumption of N, P, K in tons in Andhra Pradesh

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
Year	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
1996-97	600106	599472	1199578	249046	187338	436384	65039	67775	132814	914191	854585	1768776
1997-98	561349	513907	1075256	299741	191817	491558	62733	67476	130209	923823	773200	1697023
1998-99	620978	663277	1284255	302265	258198	560463	60484	102709	445808	983727	1024184	2007911
1999-00	681923	632648	1314572	333432	269528	602960	105563	95541	201105	1120918	997718	2118636
2000-01	678733	683060	1361793	317039	286421	603460	104327	104992	209318	1100099	1074472	2174571
2001-02	498021	684696	1182717	244935	302900	547835	95332	131192	226524	838288	1118788	1957076

Table 7.8: Yearly consumption of N, P, K in tons in Himachal Pradesh

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
Year	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
1996-97	14178	11888	26066	460	3182	3642	258	2785	3043	14896	17855	32751
1997-98	14227	12775	27002	708	3674	4382	383	3085	3468	15318	19534	34852
1998-99	15724	13416	29140	810	4409	5219	470	3728	4198	17004	21553	38557
1999-00	14912	12681	27593	1383	4379	5762	711	3277	3988	17006	20337	37343
2000-01	15345	9073	24418	1269	5271	6540	678	3916	4594	17292	18260	35552
2001-02	14430	13073	27503	1304	5739	7043	730	4880	5610	16464	23692	40156

As an illustration of accounts of pollution loads from the fertilizer use in agriculture, the fertilizer residuals in the forms of various metals are estimated for different districts in AP and HP as given Tables 7.9 and 7.10. Given the data from the specially designed farm surveys, similar type of accounts could be developed for nitrates, phosphates and other chemical residues in soil and water in different areas. These pollution loads in different locations get reflected in the ambient quality of surface and ground water reported in General Appendix A1.

Table 7.9: Metal content in total consumption of fertilizers during the year 2001-02 in AP

		Metal content in NPK (Kg)				
District	***NPK (tons)***	***Cadmium***	***Chromium***	***Copper***	***Lead***	***Zinc***
Srikakulam	39208	192.12	2128.99	325.43	125.47	3822.78
Vizianagaram	25948	127.15	1408.98	215.37	83.03	2529.93
Vishakhapatnam	28127	137.82	1527.30	233.45	90.01	2742.38
East Godavari	146987	720.24	7981.39	1219.99	470.36	14331.23
West Godavari	171002	837.91	9285.41	1419.32	547.21	16672.70
Krishna	177713	870.79	9649.82	1475.02	568.68	17327.02
Guntur	171944	842.53	9336.56	1427.14	550.22	16764.54
Prakasam	91737	449.51	4981.32	761.42	293.56	8944.36
Nellore	77427	379.39	4204.29	642.64	247.77	7549.13
Coastal Andhra	930093	4557.46	50504.05	7719.77	2976.30	90684.07
Kurnool	124967	612.34	6785.71	1037.23	399.89	12184.28
Anantapur	67064	328.61	3641.58	556.63	214.60	6538.74
Cuddapah	54236	265.76	2945.01	450.16	173.56	5288.01
Chittoor	46858	229.60	2544.39	388.92	149.95	4568.66
Rayalaseema	293125	1436.31	15916.69	2432.94	938.00	28579.69
Andhra Region	1223218	5993.77	66420.74	10152.71	3914.30	119263.76
Ranga Reddy/Hyd	103284	506.09	5608.32	857.26	330.51	10070.19
Nizamabad	78154	382.95	4243.76	648.68	250.09	7620.02
Medak	48861	239.42	2653.15	405.55	156.36	4763.95
Mehbubngr	59449	291.30	3228.08	493.43	190.24	5796.28
Nalgonda	104592	512.50	5679.35	868.11	334.69	10197.72
Warangal	105855	518.69	5747.93	878.60	338.74	10320.86
Khammam	71766	351.65	3896.89	595.66	229.65	6997.19
Karimnagar	129587	634.98	7036.57	1075.57	414.68	12634.73
Adilabad	32310	158.32	1754.43	268.17	103.39	3150.23
Telengana	733858	3595.90	39848.49	6091.02	2348.35	71551.16
STATE	1957076	9589.67	106269.23	16243.73	6262.64	190814.91

Table 7.10: Metal content in total consumption of fertilizers in HP during the year 2001-2002.

Metal content in NPK (Kg)						
District	**N, P, K (tons)**	***Cadmium***	***Chromium***	***Copper***	***Lead***	***Zinc***
Bilaspur	1980	9.702	107.514	16.434	6.336	193.05
Chamba	1129	5.5321	61.3047	9.3707	3.6128	110.0775
Hamirpur	2203	10.7947	119.6229	18.2849	7.0496	214.7925
Kangra	7903	38.7247	429.1329	65.5949	25.2896	770.5425
Kinnaur	116	0.5684	6.2988	0.9628	0.3712	11.31
Kullu	2477	12.1373	134.5011	20.5591	7.9264	241.5075
L/spiti	218	1.0682	11.8374	1.8094	0.6976	21.255
Mandi	5847	28.6503	317.4921	48.5301	18.7104	570.0825
Shimla	7386	36.1914	401.0598	61.3038	23.6352	720.135
Solan	3418	16.7482	185.5974	28.3694	10.9376	333.255
Sirmaur	2484	12.1716	134.8812	20.6172	7.9488	242.19
Una	4995	24.4755	271.2285	41.4585	15.984	487.0125
State tot	40156	196.7644	2180.4708	333.2948	128.4992	3915.21

The high yielding varieties of crops are affected by most of the insect pests and diseases like viral bacterial and fungal. Almost all the pesticides, which are used in large quantities to protect the crops, are toxic in nature. Indiscriminate use of pesticides may leave toxic residues in food grains, fodder, vegetables, and also in soil and water (Dhaliwal and Singh, 1993). The aquatic animals, fish and wild life have also been severely affected by the use of pesticides. In fact, there are several cases of insects developing resistance to insecticides such as in cotton, and in spite of this, farmers have been indulging in indiscriminate use of pesticides in such crops. Several state agricultural universities and national research institutes have revealed that waters in big lakes and the major rivers of India are contaminated with HCH and DDT residues. Incidence of contamination is about 80 % in food commodities such as milk and milk products, fruits and vegetables and animal products such as fish, eggs and meat. Also, about 20-25% of the commodities have shown pesticide residues above the maximum residue limits (MRL) as opposed to 1-2% in western countries. India consumes about 3.7% of the world total consumption. Particularly, we are using about 80000 metric tons of technical grade pesticides. Total consumption of pesticides in Andhra Pradesh is given Table 7.11.

For example a research project on `Contribution of Agricultural Application of Pesticides on Quality of Ground and River Water' sponsored by the Ganga Project Directorate, Ministry of Environment and Forests, Government of India, has monitored Ganga river water, ground water and soil from the fields along the banks of Ganga at Farrukhabad for three years for the pesticide residues (IARI, 2002). This study has found that most of the samples are contaminated with insecticides and pesticides. Also, a mathematical model of the transport of pesticides from soil to river through surface run-off, sedimentary transport, and ground water movement was developed. The model predicts that out of total 1938 grams per hectare pesticide found in top-soil, 3.624 grams was transported to the river and 0.505 grams are leached down to the ground water.

Table 7.11: Consumption of pesticide in AP (technical grade) from 1994-95-2002-03

1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
9334	10957	8702	7298	4741	4054	4000	3900	3400.7

Some estimates of pesticide contamination are given below for different water bodies and for milk products such as butter in the state of Andhra Pradesh and for bovine milk in the state of Himachal Pradesh

Table 7.12: Pesticide contamination in water bodies in AP

Location	Water body	Year	Pesticides Detected (ppb)			
			$\Sigma - DDT$	$\Sigma - HCH$	*OtherOCs*	*OPs*
Andhra Pradesh	Tanks	1993-96	ND-15.0	4.4-20.9	ND-8.3	-
	River Krishna	1997	4-17	23-51	19.16	-
	River Godavari	1997	ND	1.18-44.0	ND	-

Notes: EPA: MRL for drinking water=5ppb; Tr=Traces; ND=Not Detectable; OCs= Organochlorines; OPs= Organophosphates

Table 7.13: Pesticide contamination in butter in AP

Location	Year	Number of Samples		Pesticides Detected (ppm)	
Andhra Pradesh	1989-92	Analysed	Contaminated	$\Sigma - DDT$	$\Sigma - HCH$
		175	175	0.01-5.84	0.22-5.8

Notes: MRL: $\Sigma - DDT$ =1.25 ppm; $\Sigma - HCH$ =0.2 ppm; Tr=Traces

Table 7.14: Pesticide contamination in bovine milk in HP

Location	Year	Number of Samples		Pesticides Detected (ppm)		
Himachal Pradesh	1992-96	Analysed	Contaminated	$\Sigma - DDT$	$\Sigma - HCH$	$OtherOCs$
		204	183	>MRL 45%	-	-

Notes: MRL (ppm): $\Sigma - DDT$ = 1.25 (Fat Basis); =0.05 (Whole Milk Basis)

7.5 Conclusion

Generalized farm production accounts with the satellite accounts describing the environmental effects of farm production practices provide empirical micro foundations to develop environmental and economic accounting for estimating environmentally corrected NNP. Specially designed farm surveys covering a very large sample of farms representing different agro-climatic regions and crops have to be used to collect the data for developing these accounts.

Attempts have to be made to identify the empirical relations between the pollution from farms and the quality of local environmental media like soil, ponds, lakes, and rivers in each agro-climatic region in the state. Information about such relationships could help to design methods for mitigating environmental damages from the use of fertilizers and pesticides in agriculture. There can be several ways to minimize the adverse effects on soil and water bodies. For instance, the organic manures (which are water soluble and degradable) can be used in combination with inorganic fertilizers in an appropriate crop rotation system. Also, the efficiency of use of chemical fertilizers may be improved. Integrated pest management has been advocated widely wherein the use of selective and relatively safe pesticides may help to reduce the pollution from the use of pesticides.

Illustration of pollution accounts of agriculture for two states; AP and HP in India highlight the information required and methods to be used for collecting that information and the methodology for developing the satellite accounts of pollution from the agriculture. Unlike the industrial pollution dealt with in Chapter VI, it is difficult to estimate the contribution of agriculture to changes in pollution loads as defined in Chapter II the estimates required to estimate the environmentally corrected net value added by the agriculture.

References

Aigner, D. J. et al. (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models", *Journal of Econometrics* 6: 21-37.

Aigner, D.J. and S.F. Chu (1968), "Estimating the Industry Production Function", *American Economic Review* 58: 826-39.

Anderson, Robert J., and Thomas D. Crocker (1971), "Air Pollution and Residential Property Values", *Urban Studies* 8: 171-80.

Anderson, Robert J., and Thomas D. Crocker (1972), "Air Pollution and Property Values-A Reply", *Review of Economics and Statistics* 54: 470-73.

Barbara, A.J., and V.D. McConnell, (1990), " The Impact of Environmental Regulations on Industry Productivity: Direct and Indirect Effects", *Journal of Environmental Economics and Management.* 18: 50-65

Blackley, Paul., James, R. Follain, and Jr. Jan Ondrich (1984), "Box-Cox estimation of Hedonic Models: How serious is the Iterative OLS", *The Review of Economics and Statistics* 66: 348-53.

Box, G. and D. Cox (1964), "An Analysis of Transformations", *J. Roy. Statist. Soc. Ser. B.* 26: 211-52.

Central Pollution Control Board, Delhi, *Transport Fuel Quality Report*, 2005

Central Road Research Institute, *Urban Air Traffic and Air Pollution Report*, Chapter 8

Christensen, L., D. Jorgenson and L. Lau (1971), "Conjugate Duality and Transcendental Logarithmic Production Function", *Econometrica* 39: 255-56.

Christensen, P.P. (1989): "Historical Roots for Ecological Economics-Biophysical Versus Allocative Approaches", *Ecological Economics*. 1, pp. 17-36

Coggins, J.S., and J.R. Swinton (1996), "The Price of Pollution: A Dual Approach to Valuing SO2 Allowances", *Journal of Environmental Economics and Management* 30: 58-72.

Conrad, K., and C.J. Morrison, (1989), " The Impact of Pollution Abatement Investment on Productivity Change: An Empirical Comparison of the U.S, Germany and Canada", *Southern Economic Journal*, January, 684-698.

Dales, J.H. (1968), *Pollution, Property and Prices*. Toronto: University of Toronto Press.

Daly, H. (1990), "Commentary: Toward some operational principles of sustainable

Development", *Ecological Economics*, Vol. 2, 1-6.

Dasgupta, P. and K.G. Maler (1998), "Decentralisation Schemes, Cost-Benefit Analysis, and Net National Product as Measure of Social Well Being", *The Development Economics Discussion Papers Series* No.12, LSE, STICERD.

Diewert,W. (1974), "Functional forms for Revenue and Factor Requirement Functions", *International Economic Review* 15: 119-30.

Dumont, M., G. Rayp, P. Willeme, O. Thas, (2003). "Correcting Standard Error in Two-Stage Estimation Procedures with Generated Regressands", Working paper no. D2003/7012/10, Universitiet Gent.

Fare R., S. Grosskopf, and J. Nelson (1990), "On Price Efficiency", *International Economic Review* 31: 709-20.

Fare R., S. Grosskopf, C.A.K. Lovell and S. Yaisawarng (1993), "Derivation of Shadow Prices for Undesirable Outputs: A Distance Function Approach ", *Review of Economics and Statistics* 75: 375-80

Fare, R. (1988). *Fundamentals of Production Theory*, Berlin: Springer-Verlag.

Fare, R. and D. Primont (1995), *Multi-Output Production and Duality: Theory and Applications*. Netherlands: Kluwer Academic Publishers.

Fare, R. and S. Grosskopf (1998). "Shadow Pricing of Good and Bad Commodities", *American Journal of Agricultural Economics* 80: 584-90.

Fare, R., S. Grosskopf and C. A. K. Lovell (1994), *Production Frontiers*, Cambridge: Cambridge University Press.

Fare, R., S. Grosskopf, C. A. K. Lovell, and C. Pasurka (1989) " Multilateral Productivity Comparisons when Some Outputs are Undesirable: A Non- Parametric Apprach", *Review of Economics and Statistics*. 71: 90-98.

Feenstra R.C., and G.H. Hanson (1997). "Productivity measurement and the impact of trade and technology on wages: estimates for the US 1972-1990", *NBER Working paper* no 6052.

Feenstra R.C., and G.H. Hanson (1999) "The impact of outsourcing and high technology capital on wages: estimates for the United States", 1979-1990," *Quarterly Journal of Economics* 114 (3): 907-40.

Freeman, A.Myrick III, (1974a). “Air Pollution and Property Values A Further Comment”, *Review of Economics and Statistics* 56: 454-56.

Freeman, A.Myrick III, (1974b), “On Estimating Air Pollution Control benefits from Land Value Studies”, *Journal of Environmental Economics and Management* 1: 74-83.

Freeman, III, A.M. (1993): *The Measurement of Environmental and Resource Values: Theory and Methods*, Washington D. C: Resources for the Future.

Frisch, R. (1965). *Theory of Production*, Dordrecht: D. Reidel Publishing Company/ Holland.

Gollop, F. M, and M.I. Roberts (1983) “Environmental Regulations and Productivity Growth: The Case of Fossil-Fueled Electric Generation”, *Journal of Political Economy* 101: 654-74

Goodman, C. Allen, (1978), “Hedonic prices, Price Indices and Housing Markets”, *Journal of Urban Economics*. 5: 471-84.

Government of Andhra Pradesh, Directorate of Economics and Statistics, Statistical *Abstracts of Andhra Pradesh*, various issues.

Government of Himachal Pradesh, Directorate of Economics and Statistics, *Statistical Abstract of Himachal Pradesh*, various issues.

Government of India, *Annual Survey of Industries*, Central Statistical Organization, various issues

Government of India, *Report of the Expert Committee on Auto Fuel Policy Report*, August 2002

Gray, W.B, and S.J Shadbegian (1993), “ Environmental Regulation and Manufacturing Productivity at the Plant Level”, *Working Paper* No 4321, National Bureau of Economic Research, Washington.

Gray, W.B, and S.J Shadbegian (1995) “Pollution Abatement Cost Regulation and Plant Level Productivity”, *Working Paper* No 4964, National Bureau of Econoimc Research, Washington.

Griliches, Z. (1967). “Hedonic prices Index Revisited: Some Notes on the State of the Art, in ‘*1967 Proceedings of the Business and Economic Statistics Section*”, pp.324-32, American Statistical Association.

Hakuni, M. (1994), “ Efficiency in the Finnish Sulphate Paper Industry in 1972-90”, Finnish Forest Research Institute, *Research Report* No. 157

Halvorsen, Robert, and H.O. Pollakowski (1981), "Choice of Functional Form for Hedonic Prices Equation", *Journal of Urban Economics* 10: 37-49.

Hartwick, J. M (1990), "Natural Resources, National Accounting and Economic Depreciation", *Journal of Public Economics*, 43, pp. 291-304.

Hartwick, J. M. (1977), "Intergenerational Equity and the Investing of Rents from Exhaustible Resources", *American Economic Review*. 66, pp.972-974.

Hartwick, J. M. (1978a), "Investing Returns from Depleting Renewable Resources and Intergenerational Equity", *Economics Letters*. 1, pp. 85-88.

Hartwick, J. M. (1978b): "Substitution Among Exhaustible Resources and Intergenerational Equity", Review *of Economic Studies*. 45, pp. 347-354.

Haskel, J., and M.J. Slaughter (2001), "Trade technology and UK wage inequality", *The Economic Journal* 111: 163-87.

Haskel, J., and M.J. Slaughter (2002). "Does the Sector Bias of Skill-biased Technical Change Explain Changing Skill Premia?", *European Economic Review* 46:1757-83.

Hidano, Noboru (2002), "The Economic Valuation of the Environmental and Public Policy: A Hedonic Approach UK", Edward Elgar Publishing Limited.

Horowitz, Joel L. (1986), "Bidding Models of Housing Markets", *Journal of Urban Economics* 20:168-90.

James, A. J., and M. N. Murty (1999), " Measuring Non-users Benefits from Cleaning Ganges", *Working Paper* Series No. E/202/99, Institute of Economic Growth, Delhi.

Jorgenson, D, and P. J. Wilcoxen (1990), " Environmental Regulation and US Economic Growth", RAND *Journal of Economics* 21: 314-340

Kanemoto, Yoshitsugu (1988), "Hedonic Prices and the Benefits of Public Projects" *Econometrica* 56: 981-89.

Kiel, K.A. (1995), "Measuring the Impact of the Discovery and Cleaning of Identified Hazardous Waste sites on House Values", *Land Economics* 71: 428-35.

Kiel, K.A. and K.T. McClain (1995), "The Effect of an Incinerator Sitting on Housing Appreciation Rates", *Journal of Urban Economics* 37: 311-23.

Klassen, G., and H. Opschoor (1991), "Economics of Sustainability of Economics", *Ecological Economics*,4, pp. 83-92

Kumar, Surender (1999), " Economic Evaluation of Development Projects: A case Analysis of Environmental AND Health Implication of Thermal Power Projects in India", A Ph.D Thesis submitted to Jawaharlal Nehru University, New Delhi.

Lansford, N.H. and Lonnie Jones (1995), "Recreational and Aesthetic Value of Water via the Hedonic prices Analysis", *Journal of Agricultural and Resource Economics* 20: 341-55.

Lau, L. (1974), "Application of Duality Theory: A comment", in *Frontiers of Quantitative Economics* (M. Intriligator and D. Kendrick Eds.), Amsterdam: Vol. 2: 176-199 North Holland.

Lind, Robert C. (1973), "Spatial Equilibrium, the Theory of Rents, and the Measurement of Benefits from Public Program", *Quarterly Journal of Economics,* 87: 188-207.

Linneman, P. (1980), "Some Empirical Results on the Nature of Hedonic Property Functions for the Urban Housing Market", *Journal of Urban Economics* 8: 47-68.

Mahan, B.L., S. Polasky, and R.M. Adams (2000), "Valuing Urban Wetlands A Property Price Approach", *Land Economics* 76: 100-13.

Maler, K.G. (1991), "National Accounts and Environmental Resources", *Environmental and Resource Economics.* 1, pp. 1-15.

Markandya, A. and P. W. Abelson (1985), "The Interpretation of Capitalised Hedonic Prices in a Dynamic Environment", *Journal of Environmental Economics and Management,* pp.12195-206.

Mehta, S, et al. (1995), " Controlling Pollution: Incentives and Regulation", Sage, Delhi

Mendelsohn, R. (1987), "A Review of Identification of Hedonic Supply and Demand Functions", *Growth and Change* 18: 82-92.

Michaels, G.R.and Smith, V.K. (1990), " Market Segmentation and Valuing Amenities with Hedonic Models: The Case of Hazardous Waste Sites", *Journal of Urban Economics* 28(2): 223-42.

Ministry of Shipping, Road Transport and Highways, GOI

Mishra, S. (1999), "Water Pollution Abatement in Small – scale Industries: An Exploration of Collective Action Possibilities in Nandesari Industrial Area in Gujrat", A Ph.D Thesis submitted to the University of Delhi, Delhi.

Mitchell, R. C. and R. T. Carson, (1989), "*Using Surveys to Value Public Goods: The Contingent Valuation Method*", Resources for the Future, Washington D.C.

Murdoch, James C., and Mark J. Thayer (1988), “Hedonic Prices Estimation of Variable Urban Air Quality”, *Journal of Environmental Economics and Management* 15(2): 43-46.

Murty, M. N. James, A. J., and Smita Mishra (1999), Economics of Industrial Pollution: Indian Experience, New Delhi: Oxford University Press.

Murty, M.N and Anil Markandya (2000), “Cleaning Up the Ganges: The Cost Benefit Analysis of Ganga Action Plan”, New Delhi: Oxford University Press.

Murty, M.N and Anil Markandya (2004), “The Cost Benefit Analysis of Clearing Ganges: Some Emerging Environmental and Development Issues”, *Environmental and Development Economics.*

Murty Sushama and R.R. Russell (2002), “ On Modelling Pollution”, Mimeograph Department of Economics, University of California, Riverside, U.S.A.

Murty, M.N. (2003). “Measuring Environmentally Corrected Net National Product: Case Studies of Industrial Water Pollution and Urban Air pollution in India”, Proceedings of the Fourth National Workshop on Environmental Statistics, Central Statistical Organization, Government of India.

Murty, M.N. and Surendar Kumar (2004), *Environmental and Economic Accounting for Industry*, New Delhi, Oxford University Press.

Murty, M.N. and Surendar Kumar (2003).,“Win-win Opportunities and Environmental Regulation: testing of Porter hypothesis for Indian manufacturing industries”, *Journal of Environmental Management* 67:139-44.

Murty, M.N. Gulati, S.C. and Pitamber Chettri (2003), “Valuation and Accounting of Urban Air Pollution in the Indian Subcontinent”, Monograph, South Asian Network of Economic Institutions (SANEI).

Murty, M.N., S.C. Gulati and Pitamber Chettri (2003), “Valuation and Accounting of Urban Air Pollution in the Indian Subcontinent”, Monograph, South Asian Network of Economic Institutions (SANEI).

Murty, M.N., S.C. Gulati, and A. Banerjee (2003), Hedonic Property Prices and Valuation of Benefits from Reducing Urban Air Pollution in India”, *Working paper* no. E 237/2003, Institute of Economic Growth, Delhi.

Murty, M. N. and Anil Markandya (2004), " The Cost Benefit Analysis of Clearing Ganges: Some Emerging Environmental and Development Issues", *Environmental and Development Economics.*

Murty, M.N. and Surender Kumar (2004), "Environmental and Economic Accounting for Industry", New Delhi, Oxford University Press.

Murty, M.N., Surender Kumar and Mahua Paul " Environmental Regulation, Productive Efficiency and Cost of Pollution Abatement: A case study of Sugar Industry in India", Forthcoming in *Journal of Environmental Management*.

Myers, J.G., and L. Nakamura, (1980), "Energy and Pollution Effects on Productivity: A putty-Clay Approach", in Kendrick eds, "New Developments in Productivity Measurment and Analysis", University of Chicago Press.

Nelson, Jon P. (1978), "Residential Choices, Hedonic prices and the Demand for Urban Air Quality", *Journal of Urban Economics* 5(3): 357-69.

Pandey, Rita (1998), " Pollution Taxes for Industrial Water Pollution Control", Mimeo, National Institute of Public Finance and Policy, New Delhi.

Parikh, K.S. (1994), "Economic Valuation of Air Quality Degradation in Chembur, Bombay", *IGIDR Project Report.*

Parsons, G.R. (1992), "The Effect of Coastal Land Use Restrictions on Housing Prices A Repeat Sale Prices", *Journal of Environmental Economics and Management* 22: 25-37.

Pearce, D.W et al. (1989), Blue Print for a Green Economy, Earthscan: London.

Pearce, D.W., and R.K. Turner (1990), "Economics of Natural Resources and the Environment", Hemel Hemstead-Harvester-Wheatsheaf.

Pendleton, L., and R. Mendelsohn (2000), "Estimating Recreation Preferences Using Hedonic Travel cost and Random Utility Models", *Environmental and Resource Economic*, 17: 89-108.

Pines, David, and Yoram Weiss, (1976), "Land Improvement Projects and Land Values", *Journal of Urban Economics* 3: 1-13.

Pittman, R.W. (1981), "Issues in Pollution Interplant Cost Differences and Economies of Scale", Land Economics 57: 1-17

Pittman, R.W. (1983), "Multilateral Productivity Comparisons with Undesirable outputs", *Economic Journal*, 93: 883-891.

Polinsky, S, A. Mitchell, and Steven Shavell (1976), " Amenities and Property Values in a Model of an Urban Area", *Journal of Public Economics* 5: 119-29.

Portney, P. R. (1981), "Housing Prices, Health Effects and Valuing Reduction in Risk of Death", Journal *of Environmental Economics and Management,* 8: 72-78.

Prices for Undesirable Outputs, "A Distance Function Approach" *Review of Economics and Statistics* 75: 375-80.

Report of the Expert Committee on Auto Fuel Policy Report, Government of India, August 2002.

Ridker, Ronald G. (1967), "Economic Costs of Air Pollution Studies in Measurement New York", Praeger.

Ridker, Ronald G. and John A. Henning (1976) "The Determinants of Residential Property Values with Special Reference to Air Pollution," *Review of Economics and Statistics* 49: 246-57.

Rosen, S. (1974), "Hedonic Prices and Implicit Markets, Product Differentiation in Pure Competition", *Journal of Political Economy,* 82: 34-55.

Samuelson, P. (1961), "The Evaluation of Social Income: Capital Formation and wealth", In the *Theory of capital, Proceedings of an IRA conference,* Lutz and Hague, eds. , Newyork, St. Martin's Press, 1961.

Sen, Akshay (1994), "Determinants of Residential House Price: A Case Study of Delhi", (M.Phil Dissertation, Delhi School of Economics) Delhi.

Shepard (1970), *Theory of Cost and Production Functions*, Princeton University Press

Solow, R.M. (1974), "The Economics of Resources or the Resources of Economics", *American Economic Review,* 64, pp. 1-14.

Statistical Abstracts of Andhra Pradesh, Directorate of Economics and Statistics, Government of Andhra Pradesh, various issues.

S*tatistical Abstracts of Himachal Pradesh,* Directorate of Economics and Statistics, Government of Himachal Pradesh, various issues.

Terleckyi, N. (ed) *Household Production and Consumption* (1976), New York: Columbia University Press.

Thaler, R. and S Rosen (1976), "The Value of Life Savings", Household Production and

The Tata Energy Research Institute (TERI), *Report on Incentives for Cleaner Automobiles.*

Transport Fuel Quality Report, 2005, Central Pollution Control Board, Delhi.

UN (1993 b), *"Integrated Environmental and Economic Accounting"*, *Interim version* (Sales No. E93 XVII. 12), United Nations, New York.

UN (1993), "Integrated Environmental and Economic Accounting", Interim version (Sales No. E93 XVII. 12), New York, United Nations.

Urban Air Traffic and Air Pollution Report, Central Road Research Institute, Chapter 8.

Weitzman, M. (1976), "On the Welfare Significance of National Product in a Dynamic Economy", *Quarterly Journal of Economics*, 90:156-62

Weitzman, M. (1976), "On the Welfare Significance of National Product in a Dynamic Economy", *Quarterly Journal of Economics*, 90, pp.156-162

Yaisawarng, S, and Klein, D.J. (1994), "The Effects of Sulphur Dioxide Controls on Productivity Change in the U.S. Electric Power Industry", *Review of Economics and Statistics* 96, pp. 447-460.

Appendix to Chapter IV: A4

Household Survey in Hyderabad for Estimating Household Values of Urban Air Quality Using Hedonic Prices Models

(Survey of Working Member Households)

Section I: Socio-Economic Characteristics

Kindly answer the following questions.

1. Your name

2. Address

3. Age   4) Telephone number

5. Family size (Specify Number only):
   a) Male members:
   b) Female members:
   c) Working members:
   d) School/College going members:
   e) Members staying at home:

6. Education level:

	Adult 1	Adult 2	Adult 3	Adult 4	Adult 5
a) Up to class XII					
b) Undergraduate					
c) Postgraduate					
d) Professional qualification					
e) Other (kindly mention)					

Section II: Hedonic Property Values Model

Structural characteristics of the house

1. Age of the house:

2. House status:
   (i) (a) Flat, (b) Independent, (c) Bungalow

   (ii) (a) Rented (b) Owner occupied (c) Government or office provided

3. Area covered:

(a) Covered or plinth area

(b) Plot area in case of independent house

4. Number of floors

5. Number of living rooms (Bed room plus drawing room) in each floor.

6. How many rooms are AC or have Air coolers

7. How many bathroom cum toilets are there in the house?

8. Drainage:

   (a) Connected to public sewer, (b) On ground disposal in a well or open drain.

9. Indoor pollution:

   9.1 Source of water supply:

   (i) Drinking: (a) piped, (b) tube well, (c) dug well or river (d) any others, specify

   (ii) Bathing: (a) piped, (b) tube well, (c) dug well or river

   If piped water, duration of piped water supply

   9.2 Ventilation:
   (a) Chimney, (b) Exhaust fan, (c) Any other

   9.3 Cooking fuel:
   (a) Kerosene, (b) LPG, (c) Firewood, (c) Coal (d) Electricity, (e) Any other

   9.4 Hours of uninterrupted supply of electricity in your house

10. Property Price

    (i) Monthly/ Annual rent for the house. If owner occupied what exactly is the potential rent for an identical type of house in that locality?

    (ii) Market price of house if sold now

    (iii) Price per square meter of land: (a) Market, (b) Government

    (iv) Ownership of Property: (a) Purchased (b) Inherited

Neighborhood Characteristics

11. How far are the following from your house?

(i) Business Centre (Where most offices and business houses are situated)

(ii) Super Market complex (An area where one can get consumer durables and clothes)

(iii) Grocery market and market for daily use items

(iv) Bus stop

(v) Railway Station

(vi) Airport

(vi) Recreational areas like Park, some greenery or an open place where people go in the evening for relaxing or for a walk.

(vii) How many hospitals and nursing homes are there in this locality?

(viii) Distance from the nearest good Hospital

(ix) Distance from Hospital you usually visit

(x) Distance from the school your children go to

(xi) Distance from the nearest good school

(xii) How many Slums are in this locality, what is the distance form the nearest slum.

(xiii) How far is the Municipal Waste Bin from the house?

(xiv) Distance form the nearest main Road

(xv) Distance from nearest Industrial area

(xvi) Number of crimes in your locality last year

(a) Burglary, (b) Murder, (c) Molestation

(xvii) Which is the majority class staying here?

(A) Occupation: (a) Business class, (b) Salaried Class

(B) Religion: (a) Hindu, (b) Muslim, (c) Christian, (d) Others

12. Are their any potential property value enhancing/reducing activities going to take place in near future in your locality? Examples – metro railway, district shopping center / sports center /improvement to the road connecting to the central city etc. Please mention them.

Environmental Characteristics

13. How many parks are there in the locality? What is their area approximately?

14. Is the area prone to water logging in Monsoon?

    (a) Yes, (b) No

15. Is there any solid waste management in your locality?

    (a) Yes, (b) No

16. What is the extent of green cover in your locality?

    (a) Good, (b) Bad

17. What is your perception about the air quality in the locality?

    (a) Good, (b) Bad

18. Has you or any one of your family members stayed indoors during last year to avoid sickness due to exposure to Air Pollution? Yes / No

Section III: Hedonic Wage Model **(Working Member 1)**

These questions are to be asked to all the working members of the household

1. Gender of respondent: Male / Female

2. Address of work place

3. Educational qualifications:
   (a) Years spent in education (School, College, University):
   (b) Certificates/Degrees/Diplomas obtained:

4. Type of job:
   (i) (a) Engineers, (b) Doctors, (c) Academic, (d) MBA/CA, (e) Factory Worker (f) Any other specify
   (ii) Supervisory responsibility: Y/N
   (iii) Number of years of experience in the current job:

5. Job satisfaction in terms of use of skills of education
   (a) Low, (b) Medium, (c) High

6. Opportunities for carrier development or advancement
   (a) Low, (b) Medium, (c) High

7. Probability of involving in accidents while working
   (a) Low, (b) Medium, (c) High

8. (a) Number of accidents in your work place last year
   (b) Number of fatal accidents

9. Probability of exposure to pollution (air pollution or radiation) while working
   (a) Low, (b) Medium, (c) High

10. Perception of ambient air pollution in the location of work place
    (a) Good, (b) Bad

11. Hours spent in a day

  (a) at home and in its locality:
  (b) work place:
  (c) traveling:
  (d) any other:

12 Monthly wages/salary:

Section IV: Hedonic Travel Cost Method (Working Member 1)

These questions are to be asked to all the working members of the family: -

1. Work place

  (a) Distance of work place from home
  (b) Time taken in commuting
  (c) Work timings and hours worked

2. Mode of transport: Public/Private

(Public transport means Bus or minibus operated by government or a private sector company. The Private transport means travel by own or hired vehicles like taxies, three/two wheelers etc.)

If travel is by own car, is it (a) AC, (b) Non-AC

3. Do you take multiple modes of transport? Yes/No

4. Alternative routes with approximate distance and route chosen

	Distance	Time Taken	Land Marks		
			A	B	C
1					
2					
3					

(Write about two or three landmarks A, B, and C in each route. Tick mark the route chosen)

5. If you own vehicle give (a) Age of the vehicle:

(b) Price at which it was purchased:

6. How much you spend each day on travel in a house -- work place -- house trip?

If you are using your own car/two wheeler what is the approximate

(i) Per day Fuel cost:

(ii) Annual maintenance cost of vehicle:

(iii) Annual depreciation (capital cost) of the vehicle:

Section III: Hedonic Wage Model (Working Member 2)

These questions are to be asked to all the working members of the household

1. Gender of respondent: Male / Female

2. Address of work place

3. Educational qualifications:

(b) Years spent in education (School, College, University):

(b) Certificates/Degrees/Diplomas obtained:

4. Type of job:

(j) (a) Engineers, (b) Doctors, (c) Academic, (d) MBA/CA, (e) Factory Worker (f) Any other specify

(ii) Supervisory responsibility: Y/N

(iii) Number of years of experience in the current job:

5. Job satisfaction in terms of use of skills of education

(e) Low, (b) Medium, (c) High

6. Opportunities for carrier development or advancement

(f) Low, (b) Medium, (c) High

7. Probability of involving in accidents while working

(g) Low, (b) Medium, (c) High

8. (a) Number of accidents in your work place last year

(b) Number of fatal accidents

9. Probability of exposure to pollution (air pollution or radiation) while working

a. Low, (b) Medium, (c) High

10. Perception of ambient air pollution in the location of work place

a. Good, (b) Bad

11. Hours spent in a day

a. at home and in its locality:

b. work place:

c. traveling:

d. any other:

12 Monthly wages/salary:

Section IV: Hedonic Travel Cost Method **(Working Member 2)**

These questions are to be asked to all the working members of the family: -

1. Work place
   i. Distance of work place from home
   ii. Time taken in commuting
   iii. Work timings and hours worked

2. Mode of transport: Public/Private

(Public transport means Bus or minibus operated by government or a private sector company. The Private transport means travel by own or hired vehicles like taxies, three/two wheelers etc.)

If travel is by own car, is it (a) AC, (b) Non-AC

3. Do you take multiple modes of transport? Yes/No

4. Alternative routes with approximate distance and route chosen

	Distance	Time Taken	Land Marks		
			A	B	C
1					
2					
3					

(Write about two or three landmarks A, B, and C in each route. Tick mark the route chosen)

5. If you own vehicle give (a) Age of the vehicle:
   (b) Price at which it was purchased:

6. How much you spend each day on travel in a house -- work place -- house trip?

If you are using your own car/two wheeler what is the approximate

(j) Per day Fuel cost:

(ii) Annual maintenance cost of vehicle:

(iii) Annual depreciation (capital cost) of the vehicle:

Section V: Income of the Household

8. Could you kindly tell me what is your family's gross annual income from all sources?

   (In Rs.)

OR

in which category do your family's gross annual income fall

a) below Rs. 24000
b) Rs.24, 000 – Rs.48, 000
c) Rs.48, 000 – Rs.1 lakh
d) Rs.1 lakh– Rs. 2 lakhs
e) Rs.2 lakhs– Rs. 3 lakhs
f) Rs.3 lakhs– Rs. 5 lakhs
g) Above Rs. 5 lakhs.

Appendices to chapter V: A5, B5 and C5

A5.1 Vehicular Traffic and Air Pollution Loads in India

	TW	CAR	BUS	TRUCK	Others
No. of Veh(1000)	41478	7571	669	3045	6100
Avg. Dist/day km	30.99	34.99	37.76	32.675	36.19
Dist km(1000)	1285403.2	264909.29	25261.44	99495.375	220759
Load Per Day	**1000 kgs**				
CO	5141.61	675.52	113.68	497.48	1523.24
HC	4241.83	154.97	30.31	99.50	61.81
NO_x	77.12	237.09	424.39	795.96	549.69
PM	128.54	62.25	40.42	79.60	110.38
Load Per Day as Per					
Euro II					
CO	1799.56	260.94	70.73	278.59	141.29
HC	1696.73	26.49	19.45	76.61	12.36
NO_X	51.42	75.50	252.61	497.48	110.38
PM	51.42	9.27	5.81	9.95	11.04
Load Reduction Required					
as per Euro II Norms	**1000 kgs**				
CO	3342.05	414.58	42.94	218.89	1381.95
HC	2545.10	128.48	10.86	22.88	49.45
NO_X	25.71	161.59	171.78	298.49	439.31
PM	77.12	52.98	34.61	69.65	99.34
Concentration	**kg/km**				
	Bus	**Trucks**	**PCG**	**2W**	**Others**
Pre Euro (1996-00)					
CO	0.0045	0.0050	0.0026	0.0040	0.0069
HC	0.0012	0.0010	0.0006	0.0033	0.0003
NOX	0.0168	0.0080	0.0009	0.0001	0.0025
PM	0.0016	0.0008	0.0002	0.0001	0.0005
Euro 3					
CO	0.0028	0.0028	0.0010	0.0014	0.0006
HC	0.0008	0.0008	0.0001	0.0013	0.0001
NOX	0.0100	0.0050	0.0003	0.0000	0.0005
PM	0.0002	0.0001	0.0000	0.0000	0.0001

Table A5.2: Growth of Vehicles in India

Year	No of vehicles (000's)	Two wheelers (000's)	%	Car, jeep, taxi (000's)	%	Buses (000's)	%	Goods vehicles (000's)	%	Others (000's)	%
1951	306	27	8.82	159	51.96	34	11.11	82	26.8	4	1.31
1961	665	88	13.23	310	46.62	57	8.57	168	25.26	42	6.32
1971	1865	576	30.88	682	36.57	94	5.04	343	18.39	170	9.12
1981	5391	2618	48.56	1160	21.52	162	3.01	554	10.28	897	16.64
1991	21374	14200	66.44	2954	13.82	331	1.55	1356	6.34	2533	11.85
1996	33783	23252	68.83	4204	12.44	449	1.33	2031	6.01	3850	11.39
1997	37231	25729	69.01	4672	12.52	484	1.31	2343	6.07	4104	11.09
1998	41,369	28642	69.23	5138	12.35	538	1.31	2536	6.18	4514	10.94
1999	44,875	31328	72.04	5556	12.38	540	1.20	2554	5.69	4897	10.91
2000	48857	34118	70.08	6143	12.49	562	1.16	2715	5.54	5319	10.74
2001	54991	38556	70.11	7058	12.83	634	1.15	2948	5.36	5795	10.54
2002	58863	41478	70.47	7571	12.86	669	1.14	3045	5.17	6100	10.36

Source: Department of Road Transport and Highways, GOI

Appendix A5.3: Physical Accounts for AP

Table A5.3.1: Physical Accounts for CO2: 1997-98

	CO Emissions			CO_2 Emissions
District	Actual (Pre Euro 1991-95)	Proposed (B-II)	Physical Accounts (Load to be reduced)	Physical Accounts (Load to be reduced)
Srikakulam	2060.57	498.9	1561.66	2454.04
Vizianagaram	2438.79	597.99	1840.8	2892.68
Visakhapatnam	20443.09	4867.8	15575.28	24475.45
East Godavari	19179.29	4581.04	14598.25	22940.1
West Godavari	12619.74	2950.69	9669.05	15194.22
Krishna	20807.44	5402.9	15404.54	24207.13
Guntur	9565.18	2367.88	7197.31	11310.05
Prakasam	3495.99	847.23	2648.77	4162.35
Nellore	4398.22	1135.06	3263.15	5127.81
Coastal Andhra	95008.3	23249.49	71758.81	112763.84
Kurnool	6104.25	1525.51	4578.75	7195.17
Anantapur	7010.71	1841.78	5168.93	8122.6
Cuddapah	4178.82	1057.33	3121.49	4905.2
Chitoor	7462.88	1864.14	5598.74	8798.01
Rayalaseema	24756.66	6288.76	18467.9	29020.99
Ranga Reddy	11763.94	2910.48	8853.46	13912.58
Hyderabad	85758.43	20100.69	65657.74	103176.45
Nizamabad	5520.26	1333.27	4187	6579.56
Medak	3300.55	795.77	2504.78	3936.08
Mahbubnagar	3404.89	834.84	2570.05	4038.65
Nalgonda	4602.13	1034.12	3568.01	5606.88
Warangal	7705.94	1782.52	5923.42	9308.23
Khammam	5745.57	1295.13	4450.44	6993.55
Karimnager	8305.67	1913.51	6392.16	10044.82
Adilabad	1959.07	492.03	1467.04	2305.36
Telangana	138066.44	32492.34	105574.11	165902.17
Andhra Pradesh	257831.41	62030.59	195800.81	307686.99

Table A5.3.2: Physical Accounts for HC: 1997-98

			Units: Tons
HC EMISSIONS			
District	Actual (Pre Euro 1991-95)	Proposed (B-II)	Physical accounts
			(Pollution Load to be reduced)
Srikakulam	1060.33	376.45	683.87
Vizianagaram	1298.17	461.69	836.48
Visakhapatnam	11067.46	3847.28	7220.18
East Godavari	10469.14	3807.32	6661.82
West Godavari	6628.73	2426.49	4202.25
Krishna	10428.67	3803.17	6625.50
Guntur	4809.02	1735.48	3073.53
Prakasam	1670.98		1056.18
Nellore	2252.87	818.80	1434.07
Coastal Andhra	49685.37	17891.49	31793.88
Kurnool	3156.07	1070.72	2085.36
Anantapur	3782.27	1350.36	2431.91
Cuddapah	2002.26	727.96	1274.30
Chitoor	3967.65	1409.09	2558.56
Rayalaseema	12908.25	4558.12	8350.13
Ranga Reddy	6376.21	2287.78	4088.43
Hyderabad	45965.06	15207.51	30757.55
Nizamabad	2877.36	1052.87	1824.49
Medak	1592.51	571.16	1021.35
Mahbubnagar	1855.58	642.51	1213.08
Nalgonda	2221.21	792.14	1429.07
Warangal	4069.30	1406.51	2662.79
Khammam	2953.64	986.24	1967.41
Karimnager	4342.30	1523.86	2818.45
Adilabad	1068.98	365.42	703.56
Telangana	73322.15	24835.98	48486.18
Andhra Pradesh	135915.78	47285.59	88630.19

Table A5.3.3: Physical Accounts for NOX: 1997-98

			Units: Tons
NOX EMISSIONS			
District	Actual (Pre Euro 1991-95)	Proposed (B-II)	Physical Accounts
			(Pollution Load to be reduced)
Srikakulam	400.88	192.00	208.88
Vizianagaram	391.24	206.38	184.86
Visakhapatnam	2004.74	1204.66	800.08
East Godavari	1885.61	1103.83	781.78
West Godavari	1366.42	703.24	663.18
Krishna	4142.96	2456.42	1686.55
Guntur	1714.42	909.10	805.32
Prakasam	768.79	353.82	414.98
Nellore	930.45	501.06	429.38
Coastal Andhra	13605.52	7630.51	5975.01
Kurnool	1256.11	699.02	557.10
Anantapur	1474.38	866.75	607.63
Cuddapah	1138.39	543.50	594.89
Chitoor	1421.53	737.26	684.27
Rayalaseema	5290.41	2846.53	2443.89
Ranga Reddy	1417.45	844.60	572.86
Hyderabad	9371.99	5270.40	4101.59
Nizamabad	807.61	414.52	393.09
Medak	687.51	346.08	341.43
Mahbubnagar	587.33	313.21	274.11
Nalgonda	747.83	329.91	417.92
Warangal	902.98	476.09	426.89
Khammam	747.55	385.03	362.52
Karimnager	1055.69	536.07	519.62
Adilabad	433.23	220.38	212.85
Telangana	16759.18	9136.29	7622.89
Andhra Pradesh	35655.11	19613.33	16041.79

Table A5.3.4: Physical Accounts for PM: 1997-98

Unit: Tons

PM EMISSIONS			
District	Actual (Pre Euro 1991-95)	Proposed (B-II)	Physical Accounts (Pollution Load to be reduced)
Srikakulam	127.31	18.05	109.25
Vizianagaram	135.64	20.83	114.81
Visakhapatnam	898.12	161.31	736.80
East Godavari	910.10	158.67	751.43
West Godavari	623.12	104.87	518.26
Krishna	1215.68	185.73	1029.95
Guntur	548.47	83.04	465.43
Prakasam	228.39	31.42	196.97
Nellore	270.42	39.26	231.16
Coastal Andhra	4957.25	803.19	4154.06
Kurnool	365.47	53.08	312.38
Anantapur	435.00	63.62	371.38
Cuddapah	304.97	39.21	265.76
Chitoor	446.70	65.17	381.53
Rayalaseema	1552.13	221.08	1331.05
Ranga Reddy	559.67	96.46	463.21
Hyderabad	3738.54	655.03	3083.50
Nizamabad	300.20	47.21	252.98
Medak	208.52	29.55	178.96
Mahbubnagar	197.03	29.30	167.74
Nalgonda	266.26	39.32	226.94
Warangal	377.99	62.51	315.48
Khammam	291.13	46.51	244.62
Karimnager	433.47	69.20	364.27
Adilabad	126.73	17.32	109.42
Telangana	6499.54	1092.41	5407.12
Andhra Pradesh	13008.92	2116.68	10892.24

Table A5.3.5: Physical Accounts for CO_2: 1998-99

				Units: Tons
	CO EMISSIONS			**CO2 EMISSIONS**
	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Load to be reduced	Load to be reduced (CO2)
Srikakulam	1443.72	560.92	882.80	1387.26
Vizianagaram	1661.91	663.19	998.72	1569.41
Visakhapatnam	13239.88	5266.98	7972.90	12528.84
East Godavari	12861.29	4964.01	7897.29	12410.02
West Godavari	8711.25	3273.72	5437.53	8544.69
Krishna	13649.12	5764.50	7884.61	12390.11
Guntur	6464.72	2649.34	3815.37	5995.59
Prakasam	2330.95	899.79	1431.16	2248.97
Nellore	2999.56	1263.17	1736.39	2728.61
Chittoor	5129.18	2047.04	3082.15	4843.38
Cuddapah	2813.56	1145.61	1667.95	2621.06
Anantapur	4670.30	1909.13	2761.17	4338.97
Kurnool	3277.57	1305.76	1971.81	3098.56
Mahbubnagar	2447.42	915.37	1532.05	2407.51
Ranga Reddy	8121.81	3319.81	4801.99	7545.99
Hyderabad	54663.65	21694.53	32969.11	51808.61
Medak	2275.50	852.12	1423.38	2236.74
Nizamabad	3556.75	1444.02	2112.73	3320.00
Adilabad	1353.01	540.25	812.76	1277.20
Karimnagar	5656.89	2098.18	3558.71	5592.26
Warangal	5240.38	1962.06	3278.32	5151.65
Khammam	4017.14	1454.31	2562.83	4027.30
Nalgonda	2919.39	1108.29	1811.09	2846.01
AndhraPradesh	169504.95	67102.12	102402.83	160918.73

Table A5.3.6: Physical Accounts for HC: 1998-99

			Units: Tons
HC EMISSIONS			
	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Physical Accounts (Pollution Load to be reduced)
Srikakulam	912.67	424.74	487.93
Vizianagaram	1115.66	513.31	602.35
Visakhapatnam	9111.21	4164.15	4947.05
East Godavari	9280.15	4130.32	5149.84
West Godavari	6098.48	2700.60	3397.88
Krishna	8856.17	4088.62	4767.55
Guntur	4263.68	1952.61	2311.07
Prakasam	1438.28	659.17	779.11
Nellore	1965.90	907.72	1058.19
Chittoor	3340.27	1558.51	1781.76
Cuddapah	1718.56	806.32	912.24
Anantapur	3104.39	1454.32	1650.07
Kurnool	2010.93	961.87	1049.06
Mahbubnagar	1408.16	680.71	727.46
Ranga Reddy	5817.27	2616.94	3200.32
Hyderabad	34194.67	16286.88	17907.79
Medak	1377.46	634.71	742.74
Nizamabad	2550.75	1152.49	1398.26
Adilabad	826.25	402.38	423.87
Karimnagar	3619.71	1678.16	1941.54
Warangal	3293.19	1537.31	1755.88
Khammam	2296.85	1099.44	1197.41
Nalgonda	1901.88	878.80	1023.08
AndhraPradesh	110502.54	51290.07	59212.47

Table A5.3.7: Physical Accounts for NOX: 1998-99

Units: Tons			
NOX EMISSIONS			
District	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Physical Accounts
			(Pollution Load to be reduced)
Srikakulam	374.99	212.91	162.07
Vizianagaram	359.34	224.88	134.46
Visakhapatnam	1856.18	1296.60	559.58
East Godavari	1714.63	1164.68	549.95
West Godavari	1235.16	759.49	475.67
Krishna	3645.67	2539.32	1106.36
Guntur	1539.32	983.40	555.92
Prakasam	659.91	366.59	293.32
Nellore	860.84	544.36	316.48
Chittoor	1316.84	782.33	534.51
Cuddapah	974.04	557.13	416.91
Anantapur	1153.27	744.04	409.23
Kurnool	789.33	479.15	310.18
Mahbubnagar	591.57	349.13	242.44
Ranga Reddy	1358.24	935.07	423.17
Hyderabad	8888.81	5852.12	3036.69
Medak	585.50	316.67	268.83
Nizamabad	700.51	459.77	240.74
Adilabad	419.70	242.44	177.27
Karimnagar	908.16	558.71	349.45
Warangal	820.75	522.97	297.78
Khammam	724.88	440.93	283.95
Nalgonda	576.52	351.45	225.07
AndhraPradesh	32054.18	20684.15	11370.03

Table A5.3.8: Physical Accounts for PM: 1998-99

			Units: Tons
PM EMISSIONS			
	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Physical Accounts
			(Pollution Load to be reduced)
Srikakulam	70.43	20.26	50.17
Vizianagaram	72.82	23.16	49.66
Visakhapatnam	459.34	174.31	285.03
East Godavari	466.76	171.88	294.88
West Godavari	331.86	116.10	215.76
Krishna	639.76	198.27	441.49
Guntur	299.35	92.58	206.77
Prakasam	119.90	33.04	86.86
Nellore	144.46	43.10	101.37
Chittoor	238.23	71.41	166.82
Cuddapah	161.83	42.04	119.79
Anantapur	209.16	65.51	143.65
Kurnool	143.75	44.53	99.22
Mahbubnagar	114.32	33.39	80.93
Ranga Reddy	301.48	109.98	191.50
Hyderabad	1929.96	705.60	1224.35
Medak	111.05	31.31	79.74
Nizamabad	148.42	49.73	98.69
Adilabad	67.78	18.88	48.89
Karimnagar	227.02	75.50	151.52
Warangal	203.21	69.28	133.93
Khammam	166.27	52.86	113.42
Nalgonda	123.87	39.56	84.31
AndhraPradesh	6751.03	2282.27	4468.75

Table A5.3.9: Physical Accounts for CO_2: 2001-02

				Units: Tons
	CO EMISSIONS			**CO2 EMISSIONS**
District	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Load to be reduced	Load to be reduced (CO2)
Srikakulam	2183.96	822.98	1360.99	2138.69
Vizianagaram	2415.03	943.55	1471.47	2312.32
Visakhapatnam	17466.20	6866.49	10599.71	16656.68
East Godavari	17442.15	6712.24	10729.91	16861.29
West Godavari	11734.53	4585.60	7148.93	11234.04
Krishna	18211.73	7766.33	10445.40	16414.20
Guntur	8814.01	3650.83	5163.19	8113.58
Prakasam	3548.36	1545.81	2002.54	3146.85
Nellore	4360.09	1864.90	2495.19	3921.02
Chittoor	6938.07	2829.43	4108.65	6456.44
Cuddapah	2825.24	1278.29	1546.96	2430.93
Anantapur	7536.00	3074.74	4461.26	7010.55
Kurnool	5491.70	2217.77	3273.93	5144.75
Mahbubnagar	3212.17	1314.89	1897.28	2981.43
Ranga Reddy	13128.75	5391.50	7737.24	12158.52
Hyderabad	72221.05	28689.58	43531.47	68406.60
Medak	3379.30	1347.57	2031.73	3192.72
Nizamabad	5412.14	2194.76	3217.38	5055.88
Adilabad	4212.37	1568.03	2644.34	4155.39
Karimnagar	7494.14	2770.58	4723.55	7422.73
Warangal	7219.79	2706.18	4513.61	7092.82
Khammam	6007.80	2131.91	3875.88	6090.67
Nalgonda	3858.84	1519.57	2339.28	3676.00
Andhra Pradesh	235113.42	93793.53	141319.89	222074.11

Table A5.3.10: Physical Accounts for HC: 2001-02

			Units: Tons
HC EMISSIONS			
District	Actual (Pre Euro 1996-2000)	Proposed (B-II)	Physical Accounts
			(Pollution Load to be reduced)
Srikakulam	1352.09	634.76	717.33
Vizianagaram	1558.32	727.73	830.59
Visakhapatnam	11735.81	5411.06	6324.74
East Godavari	12180.98	5515.13	6665.84
West Godavari	8329.06	3728.26	4600.80
Krishna	11809.00	5542.62	6266.37
Guntur	5774.33	2695.88	3078.45
Prakasam	2204.93	1060.12	1144.81
Nellore	2790.72	1327.56	1463.15
Chittoor	4522.60	2138.09	2384.51
Cuddapah	1628.30	815.17	813.12
Anantapur	4997.51	2346.33	2651.18
Kurnool	3190.65	1564.93	1625.72
Mahbubnagar	1776.63	892.10	884.53
Ranga Reddy	9464.24	4224.64	5239.60
Hyderabad	42661.19	20703.04	21958.14
Medak	2097.84	1009.35	1088.48
Nizamabad	3545.35	1669.39	1875.96
Adilabad	2207.82	1151.42	1056.40
Karimnagar	4929.25	2264.80	2664.45
Warangal	4222.44	2062.88	2159.56
Khammam	3304.57	1628.30	1676.26
Nalgonda	2604.10	1196.15	1407.94
AndhraPradesh	148887.70	70309.72	78577.97

Table A5.3.11: Physical Accounts for NOX: 2001-02

			Units: Tons
NOX EMISSIONS			
District	Actual	Proposed (B-II)	Physical Accounts
			(Pollution Load to be reduced)
Srikakulam	464.89	270.72	194.17
Vizianagaram	472.68	307.57	165.11
Visakhapatnam	2252.83	1584.04	668.79
East Godavari	2272.69	1641.98	630.71
West Godavari	1836.35	1282.71	553.64
Krishna	4684.36	3470.46	1213.90
Guntur	1985.88	1393.02	592.86
Prakasam	1297.28	908.26	389.03
Nellore	1237.47	868.46	369.01
Chittoor	1770.93	1152.08	618.85
Cuddapah	1324.34	854.47	469.88
Anantapur	1814.16	1210.94	603.23
Kurnool	1554.31	1010.21	544.10
Mahbubnagar	1147.57	757.33	390.24
Ranga Reddy	2078.02	1328.83	749.19
Hyderabad	12561.39	7806.62	4754.77
Medak	813.74	535.24	278.50
Nizamabad	1141.65	823.63	318.02
Adilabad	998.96	641.02	357.94
Karimnagar	1023.07	634.74	388.33
Warangal	1155.41	820.68	334.73
Khammam	870.66	583.33	287.34
Nalgonda	797.55	516.33	281.22
AndhraPradesh	45556.21	30402.66	15153.55

Table A5.3.12: Physical Accounts for PM: 2001-02

			Units: Tons
PM EMISSIONS			
District	Actual	Proposed (B-II)	Physical Accounts (Pollution Load to be reduced)
Srikakulam	97.32	29.73	67.59
Vizianagaram	101.52	33.13	68.39
Visakhapatnam	582.31	226.05	356.26
East Godavari	618.87	231.43	387.44
West Godavari	449.22	159.64	289.59
Krishna	820.03	263.75	556.28
Guntur	386.48	125.49	261.00
Prakasam	197.90	54.82	143.09
Nellore	203.37	62.97	140.39
Chittoor	316.42	97.71	218.72
Cuddapah	186.38	45.81	140.56
Anantapur	332.12	105.59	226.53
Kurnool	265.19	77.66	187.52
Mahbubnagar	178.75	47.76	130.99
Ranga Reddy	466.57	174.29	292.28
Hyderabad	2574.10	920.14	1653.96
Medak	148.93	46.62	102.31
Nizamabad	225.74	75.42	150.32
Adilabad	182.51	55.46	127.05
Karimnagar	284.03	98.88	185.15
Warangal	273.83	94.79	179.04
Khammam	225.23	76.82	148.42
Nalgonda	168.36	53.95	114.41
AndhraPradesh	9285.19	3157.90	6127.29

Appendix B5: Physical Accounts for Himachal Pradesh

Table B5.1: Passenger cars (Private cars, taxi cabs, jeeps)

		CO2	HC	NOX	PM
Pollution Load (Million Kg/Year)	Pre Euro	22.196	1.709	3.774	0.743
	Euro I/ Bharat 2000	4.413	0.602	0.809	0.148
	Euro II/ Bharat II	4.153	0.404	0.586	0.090
	Euro III/ Bharat III	2.557	0.165	0.470	0.057
Load Reduced/ Physical Accounts (Million Kg/Year)	Pre Euro to Euro I	17.782	1.106	2.965	0.594
	Pre Euro to Euro II	18.0422	1.305	3.188	0.652
	Pre Euro to Euro III	19.639	1.544	3.304	0.685
	Euro I to Euro II	0.259	0.198	0.223	0.057
	Euro I to Euro III	1.856	0.437	0.338	0.090

Table B5.2: Buses

		CO2	HC	NOX	PM
Pollution Load (Million Kg/Year)	Pre Euro	2.0165	0.345	4.790	0.456
	Euro I/ Bharat 2000	1.6132	0.276	3.593	0.159
	Euro II/ Bharat II	1.434	0.248	3.136	0.068
	Euro III/ Bharat III	1.254	0.219	2.851	0.065
Load Reduced/ Physical Accounts (Million Kg/Year)	Pre Euro to Euro I	0.403	0.068	1.197	0.296
	Pre Euro to Euro II	0.582	0.096	1.654	0.387
	Pre Euro to Euro III	0.761	0.125	1.939	0.390
	Euro I to Euro II	0.179	0.028	0.456	0.0912
	Euro I to Euro III	0.358	0.0570	0.741	0.094

Table B5.3: Trucks

		CO2	HC	NOX	PM
Pollution Load (Million Kg/Year)	Pre Euro	12.441	2.128	14.778	1.407
	Euro I/ Bharat 2000	9.952	1.706	11.083	0.492
	Euro II/ Bharat II	8.847	1.530	9.676	0.211
	Euro III/ Bharat III	7.741	1.3546	8.796	0.175
Load Reduced/ Physical Accounts (Million Kg/Year)	Pre Euro to Euro I	2.488	0.422	3.694	0.914
	Pre Euro to Euro II	3.594	0.598	5.102	1.196
	Pre Euro to Euro III	4.699	0.774	5.981	1.231
	Euro I to Euro II	1.105	0.175	1.407	0.281
	Euro I to Euro III	2.211	0.351	2.287	0.316

Table B5.4: Two Wheelers

		CO2	HC	NOX	PM
Pollution Load (Million Kg/Year)	Pre Euro	9.421	4.946	0.090	0.150
	Euro I/ Bharat 2000	5.181	3.192	0.075	0.075
	Euro II/ Bharat II	3.297	1.978	0.060	0.060
Load Reduced/ Physical Accounts (Million Kg/Year)	Pre Euro to Euro I	4.239	1.754	0.015	0.075
	Pre Euro to Euro II	6.123	2.968	0.030	0.090
	Euro I to Euro II	1.884	1.214	0.015	0.015

Table B5.5: Commercial Vehicles

		CO2	HC	NOX	PM
Pollution Load (Million Kg/Year)	Pre Euro	3.552	0.092	0.816	0.164
	Euro I/ Bharat 2000	1.670	0.046	0.590	0.066
	Euro II/ Bharat II	0.236	0.021	0.193	0.023
	Euro III/ Bharat III	0.210	0.018	0.164	0.016
Load Reduced/ Physical Accounts (Million Kg/Year)	Pre Euro to Euro I	1.881	0.046	0.226	0.098
	Pre Euro to Euro II	3.316	0.071	0.622	0.141
	Pre Euro to Euro III	3.342	0.073	0.652	0.147
	Euro I to Euro II	1.435	0.025	0.396	0.043
	Euro I to Euro III	1.461	0.028	0.426	0.049

Appendix C5: Questionnaires

C5.1: Transport Sector Survey, November 2004

1. Put a tick below the correct option.

   ☐ Himachal Pradesh Registered

   or

   ☐ Tourist vehicle registered outside Himachal Pradesh

2. If it is a Tourist vehicle, then state the following.
   - Number of trips to HP in a year: ______________________________
   - Average distance traveled in HP in each trip: _____________________
   - How many days are spent in HP per trip: ________________________

3. Vehicle Category (Put a Tick below)

   a. Bus b. Truck c. Pvt. Car d. Jeep e. Taxi Cab

   g. Any other Commercial (Tractor, water carrier, any other)

4. Model and age of the vehicle:
   ____

5. Year of Purchase:
   ____

Leave question number 6 and 7 if it is a tourist vehicle.

6. Total distance traveled (as displayed by the speedometer): __________________
   ____

7. Average distance traveled per day: __________________________________

8. Does your vehicle already have any one of the following technologies when you bought it or have you converted/shifted to any of the following after you bought it?

   ☐ Euro III/ Bharat Stage III technology

   ☐ Euro II/ Bharat Stage II technology

   ☐ Euro I/ India Stage 2000 technology

- ☐ Pre Euro Norm (1996-2000) technology
- ☐ Pre Euro Norm (up to 1995) technology
- ☐ CNG Engine
- ☐ LPG cylinder
- ☐ Any other. Mention it. ____

If No Conversion, then
(a) What is the type of fuel used? a. Petrol b. Diesel c. CNG d. LPG

(b) What is the mileage (Km. per litre of petrol or diesel or per cylinder of CNG or LPG) in your vehicle?

____

(c) What is the maintenance or running cost of your vehicle (Rs.)

a. Fuel Cost	
b. Cost of repair and replacement	
c. Insurance Cost	

If Vehicle Has Undergone A Conversion, then
(a) What is the Installation/Investment Cost undertaken for conversion?

Rs. ____

(b) Fill table below.

	Before Conversion	After Conversion
1. Fuel Used		
2. Mileage		
3. Maintenance/Running Cost		
a. Fuel Cost		
b. Cost of repair and replacement		
c. Insurance Cost		

9. Have you bought a new vehicle or is it a second hand? ☐ New ☐ Second Hand

10. What is the purchase price of the vehicle?

____

11. What is the current price of the vehicle if you sell it? ____________________________

12. Any other technology/cost information____
____
____

C5.2 Questionnaire for Two Wheelers

1. Model and age of the vehicle: ____
2. Year of Purchase: ____
3. Tick the relevant option : ☐ Two Stroke ☐ Four Stroke
4. Total distance traveled (as displayed by the speedometer): ____________________
   ____
5. Average distance traveled per day: ______________________________________
6. What is the mileage (Km. per litre of petrol) in your vehicle? ________________
7. What is the maintenance or running cost of your vehicle? (Rs.)

a. Fuel Cost	
b. Cost of repair and replacement	
c. Insurance Cost	

8. Have you bought a new vehicle or is it a second hand? ☐ New
   ☐ Second hand
9. What is the purchase price of the vehicle? _________________________________
10. What is the current price of the vehicle if you sell it? _______________________

Appendices to chapter VI: A6, B6 and C6

A6.Andhra Pradesh

Table A6.1: Generalised Production Account of Leather Industry of AP

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	62	67
2	Factories in operation	51	65
3	Fixed Capital	102.3	225.4
4	Physical working capital	208.6	277.1
5	Invested capital	310.9	502.5
6	Gross value of addition to fixed cap	15	38.3
7	Rent paid for fixed assets	7.6	3.3
8	Outstanding loan	220.1	150.9
9	Interest paid	16.7	47.8
10	Gross value of plant and machinery	23.4	167.6
11	Value of prod and by-prod	865.1	788.2
12	Total o/p	994.8	900.2
13	Fuels consumed	27.4	28.9
14	Materials consumed	683.1	583.2
15	Total I/p	807.2	685.1
16	Gross value added	187.6	215.1
17	Depreciation	12.3	23.9
18	Net value added	168.8	191.2

Table A6.2: Generalised Physical and Monetary Accounts of Leather Industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	6078.935	20435.99	11116.22	5538.529	18619.4	10128.05
2	Load as per std.	178.8252	1490.21	596.0839	162.9288	1357.355	543.0934
3	Load to be reduced (1-2)	5900.11	18945.78	10520.14	5375.6	17262.05	9584.952
Monetary Accounts							
4	Cost of meeting std. (1-2)*SP	63.16599	1196.928	228.349	57.55064	1090.556	208.05

Table A6.3: Generalised Production Accounts of Fertilizer, Chemical and Drug industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	736	779
2	Factories in operation	629	744
3	Fixed Capital	45387.4	39241.7
4	Physical working capital	11086.1	14799.9
5	Invested capital	56473.5	54041.7
6	Gross value of addition to fixed cap	9406.7	8450.4
7	Rent paid for fixed assets	2825.9	447.1
8	Outstanding loan	46417.9	32475.8
9	Interest paid	6168.7	2234.2
10	Gross value of plant and machinery	47427.9	37841.9
11	Value of prod and by-prod	57131.6	58112.7
12	Total o/p	67918.1	87599.6
13	Fuels consumed	5913.4	5298.1
14	Materials consumed	31444.5	52149
15	Total I/p	46141.1	69088.3
16	Gross value added	21777.1	18511.3
17	Depreciation	3077	3509.4
18	Net value added	18700.1	15001.9

Table A6.4: Generalised Physical and Monetary Accounts of Fertilizer, Chemical and Drug industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	3982459	16360865	13991278	4050848	16641825	14231545
2	Load as per std.	683251	5693759	2277503	694984.2	5791536	2316614
3	Load to be reduced (1-2)	3299208	10667107	11713775	3355864	10850289	11914931
Monetary Accounts							
4	Cost of meeting std. (1-2)*SP	34159.78	611218.8	141505.9	34746.39	621715.1	143935.9

Table A6.5: Generalised Production Accounts of Distillery industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	5219	5553
2	Factories in operation	4681	5041
3	Fixed Capital	24813.1	24062.3
4	Physical working capital	27227.9	36696.8
5	Invested capital	52041	60759.1
6	Gross value of addition to fixed cap	3103.4	3240.3
7	Rent paid for fixed assets	529.1	456.2
8	Outstanding loan	17901.6	15760.9
9	Interest paid	4170.4	4524.3
10	Gross value of plant and machinery	18757	17161.8
11	Value of prod and by-prod	132376.9	129265.7
12	Total o/p	144555.3	144120.3
13	Fuels consumed	3894	2322.5
14	Materials consumed	83690.5	110429.7
15	Total I/p	131369.7	130466
16	Gross value added	13185.9	13654.4
17	Depreciation	8672.7	4339.9
18	Net value added	11313.2	11628.5

Table A6.6: Generalised Physical and Monetary Accounts of Distillery industry

		1998-99			2000-01		
Phy. Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	540579273.0	1268012776.4	111643076.8	1805901.0	4236021.8	176291.3
2	Load as per std.	631437.8	5261981.8	2104792.7	2109.4	17578.6	7031.4
3	Load to be reduced (1-2)	539947835.2	1262750794.6	109538284.1	1803791.6	4218443.2	169259.9
Mon. Accounts							
4	Cost of meeting std. (1-2)*SP	10094702.7	56955364.4	2962298.6	33723.1	190269.5	4577.4

Table A6.7: Generalised Production Accounts of Iron and Steel industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	212	220
2	Factories in operation	203	196
3	Fixed Capital	71270.2	53701.4
4	Physical working capital	13043.4	15741.9
5	Invested capital	84313.7	69443.3
6	Gross value of addition to fixed cap	1323	792.3
7	Rent paid for fixed assets	63.5	56.5
8	Outstanding loan	24368	32757.2
9	Interest paid	4481.5	4927.6
10	Gross value of plant and machinery	77322.8	75743.6
11	Value of prod and by-prod	38482.3	42957.2
12	Total o/p	44178.1	56318.4
13	Fuels consumed	4900.4	4864.3
14	Materials consumed	28088.9	28130.3
15	Total I/p	37792.3	45301.2
16	Gross value added	6385.7	11017.2
17	Depreciation	5190	4926.6
18	Net value added	1195.7	6090.6

Table A6.8: Generalised Physical and Monetary Accounts of Iron and Steel industry

		1998-99			2000-01		
Phy. Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	565044.7	3797835	5490366	630750.7	4239465	6128811
2	Load as per std.	1036.618	8638.48	3455.392	1157.16	9643.002	3857.201
3	Load to be reduced (1-2)	564008.1	3789197	5486910	629593.5	4229822	6124953
Mon. Accounts							
4	Cost of meeting std. (1-2)*SP	7495.724	191818.6	91501.91	8367.361	214124.2	102142.2

Table A6.9: Generalised Production Accounts of Petroleum Industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	35	42
2	Factories in operation	35	42
3	Fixed Capital	4313.7	24357
4	Physical working capital	2898.8	9882
5	Invested capital	7212.5	34238.9
6	Gross value of addition to fixed cap	1399.5	2538.2
7	Rent paid for fixed assets	32.2	47.1
8	Outstanding loan	2974.3	24972
9	Interest paid	81.3	983.7
10	Gross value of plant and machinery	6160	23155.3
11	Value of prod and by-prod	21233.2	73484.6
12	Total o/p	21347.1	74796
13	Fuels consumed	20.5	380
14	Materials consumed	18724.2	70518
15	Total I/p	19317.7	71554.5
16	Gross value added	2029.4	3241.4
17	Depreciation	291.7	1436.7
18	Net value added	1737.7	1804.7

Table A6.10: Generalised Production Accounts of Petroleum Industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	2759.698	8619.102	228.4246	9550.859	29829.29	790.5397
2	Load as per std.	20.69638	172.509	68.79195	71.62676	597.0253	238.0776
3	Load to be reduced (1-2)	2739.001	8446.593	159.6326	9479.232	29232.26	552.4621
Monetary Accounts							
4	Cost of meeting std.(1-2)*SP	37.38737	352.6453	2.000197	129.3915	1220.447	6.92235

B6.Himachal Pradesh

Table B6.1: Generalised Production Accounts of Leather Industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	4	6
2	Factories in operation	4	5
3	Fixed Capital	36	43.4
4	Physical working capital	1	127.9
5	Invested capital	37	171.2
6	Gross value of addition to fixed cap	19.2	9.8
7	Rent paid for fixed assets	0.4	1.2
8	Outstanding loan	1.7	9.4
9	Interest paid	1.4	12
10	Gross value of plant and machinery	35	47.8
11	Value of prod and by-prod	3.9	339.7
12	Total o/p	108.8	356.4
13	Fuels consumed	6.3	6.8
14	Materials consumed	25.8	273.8
15	Total I/p	54.8	294.3
16	Gross value added	54.1	62.1
17	Depreciation	3	6.5
18	Net value added	51.1	55.6

Table B6.2: Generalised Physical and Monetary Accounts of Leather Industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	27.40	92.13	50.11	2387.02	8024.63	4365.02
2	Load as per std.	0.81	6.72	2.69	70.22	585.16	234.07
3	Load to be reduced (19-21)	26.60	85.41	47.43	2316.80	7439.47	4130.96
Monetary Accounts							
4	Cost of meeting standards (19-21)*SP	0.28	5.40	1.03	24.80	470.00	89.67

Table B6.3: Generalised Production Account of Fertilizer, Chemical and Drug industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	62	70
2	Factories in operation	62	70
3	Fixed Capital	3406.3	4774.7
4	Physical working capital	1367.1	3225.7
5	Invested capital	4773.5	8000.4
6	Gross value of addition to fixed cap	2518.1	422.8
7	Rent paid for fixed assets	36.4	16.3
8	Outstanding loan	2081	3251.5
9	Interest paid	294	727.9
10	Gross value of plant and machinery	2898.7	4001.1
11	Value of prod and by-prod	4621.1	14021.9
12	Total o/p	4708.4	14078.6
13	Fuels consumed	110.5	202.4
14	Materials consumed	3070.2	9843
15	Total I/p	3422.2	10908.1
16	Gross value added	1286.2	3170.6
17	Depreciation	111.1	217
18	Net value added	1175.1	2953.6

Table B6.4: Generalised Physical and Monetary Accounts of Fertilizer, Chemical and Drug industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	322121.9	1323352	1131687	686123.7	2818755	2410508
2	Load as per std.	55264.88	460540.7	184216.3	117714.9	980957.4	392383
3	Load to be reduced (19-21)	266857.1	862810.9	947470.8	568408.8	1837798	2018125
Monetary Accounts							
4	Cost of meeting stand. (19-21)*SP	2763.02	49438.55	11445.73	5885.267	105304.7	24379.55

Table B6.5: Generalised Production Accounts of Distillery industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	23	33
2	Factories in operation	18	31
3	Fixed Capital	55.3	1244
4	Physical working capital	118	318.4
5	Invested capital	173.3	1562.4
6	Gross value of addition to fixed cap	7.1	86.6
7	Rent paid for fixed assets	69.5	11.7
8	Outstanding loan	55.9	392.9
9	Interest paid	9.8	72.4
10	Gross value of plant and machinery	33.1	578
11	Value of prod and by-prod	622.2	2778.2
12	Total o/p	637.2	2818.2
13	Fuels consumed	9.6	84.1
14	Materials consumed	377	1614.4
15	Total I/p	439.6	1884.1
16	Gross value added	197.6	934
17	Depreciation	4.6	120.7
18	Net value added	193	813.3

Table B6.6: Generalised Physical and Monetary Accounts of Distillery industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	2540839	5959934	524746.6	11345162	26611842	2343058
2	Load as per std.	2967.894	24732.45	9892.98	13252.01	110433.5	44173.38
3	Load to be reduced (19-21)	2537871	5935201	514853.6	11331910	26501408	2298885
Monetary Accounts							
4	Cost of meeting stand.(19-21)*SP	47447.28	267702.5	13923.44	211858	1195325	62169.89

Table B6.7: Generalised Production Accounts of Iron and steel industry

S. No.	Characteristic	1998-99	2000-01
1	No. of factories	20	9
2	Factories in operation	20	9
3	Fixed Capital	101.13	193.5
4	Physical working capital	484.1	63.1
5	Invested capital	1495.4	256.5
6	Gross value of addition to fixed cap	21.4	9.4
7	Rent paid for fixed assets	10.5	0.4
8	Outstanding loan	780.3	617.7
9	Interest paid	189.4	9.8
10	Gross value of plant and machinery	1234.7	311.5
11	Value of prod and by-prod	1802.7	44.3
12	Total o/p	1901.3	447.4
13	Fuels consumed	96.4	26.3
14	Materials consumed	1527	412.2
15	Total I/p	1749.5	475.6
16	Gross value added	151.8	-28.2
17	Depreciation	97.1	16.3
18	Net value added	54.7	-44.5

Table B6.8: Generalised Physical and Monetary Accounts of Iron and Steel industry

		1998-99			2000-01		
Physical Accounts		**BOD**	**COD**	**SS**	**BOD**	**COD**	**SS**
1	Influent Load (Tons)	26469.47	177909.26	257195.70	650.47	4371.99	6320.39
2	Load as per std.	48.56	404.67	161.87	1.19	9.94	3.98
3	Load to be reduced (19-21)	26420.91	177504.59	257033.83	649.27	4362.04	6316.41
Monetary Accounts							
4	Cost of meeting stand. (19-21)*SP	351.14	8985.73	4286.40	8.63	220.82	105.34

Appendices to chapter VII: A7 and B7

Table A7.1: AP (1996-97): Season wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	17438	5571	23009	4483	1085	5568	1790	638	2428	23711	7294	31005
Vizianagaram	16503	3880	20383	3985	957	4942	703	460	1163	21191	5297	26488
Vishakhapatnam	15592	5364	20956	1616	504	2120	487	563	1050	17695	6431	24126
East Godavari	40907	42671	83578	9441	14173	23614	4532	4470	9002	54880	61314	116194
West Godavari	42853	57176	100029	19663	26775	46438	7057	7530	14587	69573	91481	161054
Krishna	51110	56563	107673	24431	18266	42697	8537	10323	18860	84078	85152	169230
Guntur	53151	47205	100356	25673	12367	38040	6191	4226	10417	85015	63798	148813
Prakasam	20268	31974	52242	11825	9391	21216	2266	3308	5574	34359	44673	79032
Nellore	14643	32847	47490	8319	9309	17628	1268	4245	5513	24230	46401	70631
Coastal Andhra	272465	283251	555716	109436	92827	202263	32831	35763	68594	414732	411841	826573
Kurnool	34318	25967	60285	22414	10829	33243	5115	4674	9789	61847	41470	103317
Anantapur	15483	15509	30992	11973	5006	16979	3247	2524	5771	30703	23039	53742
Cuddapah	17635	17886	35521	11008	5771	16779	2200	2065	4265	30843	25722	56565
Chittoor	12552	15734	28286	4055	4851	8906	1574	2741	4315	18181	23326	41507
Rayalaseema	79988	75096	155084	49450	26457	75907	12136	12004	24140	141574	113557	255131
Andhra Region	352453	358347	710800	158886	119284	278170	44967	47767	92734	556306	525398	1081704
Ranga Reddy/Hyd	33025	33027	66052	8545	5790	14335	2743	2827	5570	44313	41644	85957
Nizamabad	32039	28670	60709	7347	6672	14019	920	1536	2456	40306	36878	77184
Medak	14605	18178	32783	3943	3684	7627	695	856	1551	19243	22718	41961
Mehbubngr	21401	19773	41174	12741	9210	21951	3447	2919	6366	37589	31902	69491
Nalgonda	32541	36997	69538	16488	17030	33518	3894	4612	8506	52923	58639	111562
Warangal	42925	39499	82424	13848	8787	22635	2613	2178	4791	59386	50464	109850
Khammam	25001	25764	50765	11834	5639	17473	2527	1787	4314	39362	33190	72552
Karimnagar	35808	33661	69469	11473	10057	21530	2325	3072	5447	49656	46790	96446
Adilabad	10308	5556	15864	3941	1185	5126	858	221	1079	15107	6962	22069
Telengana	247653	241125	488778	90160	68054	158214	20072	20008	40080	357885	329187	687072
STATE	600106	599472	1199578	249046	187338	436384	65039	67775	132814	914191	854585	1768776

Table A7.2: AP (1997-98): Season wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	19900	6003	25903	6610	1384	7994	2285	1319	3604	28795	8706	37501
Vizianagaram	15886	5420	21306	3635	864	4499	1292	860	2152	20813	7144	27957
Vishakhapatnam	13574	10438	24012	2105	784	2889	1070	183	1253	16749	11405	28154
East Godavari	32463	44390	76853	12812	14579	27391	5870	6403	12273	51145	65372	116517
West Godavari	37413	51544	88957	25364	28513	53877	6782	10277	17059	69559	90334	159893
Krishna	49714	47096	96810	26640	19490	46130	9488	8358	17846	85842	74944	160786
Guntur	45268	43939	89207	28831	13418	42249	4649	5816	10465	78748	63173	141921
Prakasam	16087	34868	50955	13422	11822	25244	1399	4508	5907	30908	51198	82106
Nellore	14432	36327	50759	8248	11422	19670	1946	4268	6214	24626	52017	76643
Coastal Andhra	244737	280025	524762	127667	102276	229943	34781	41992	76773	407185	424293	831478
Kurnool	27576	21599	49175	25646	11129	36775	4456	4286	8742	57678	37014	94692
Anantapur	13561	10288	23849	14524	4510	19034	3570	2457	6027	31655	17255	48910
Cuddapah	13175	18692	31867	10845	6273	17118	1747	1735	3482	25767	26700	52467
Chittoor	13982	17335	31317	5434	5336	10770	2158	3513	5671	21574	26184	47758
Rayalaseema	68294	67914	136208	56449	27248	83697	11931	11991	23922	136674	107153	243827
Andhra Region	313031	347939	660970	184116	129524	313640	46712	53983	100695	543859	531446	1075305
Ranga Reddy/Hyd	36361	24649	61010	12297	9512	21809	1243	1520	2763	49901	35681	85582
Nizamabad	34483	17473	51956	8701	5504	14205	1538	996	2534	44722	23973	68695
Medak	18249	8597	26846	7364	3704	11068	962	764	1726	26575	13065	39640
Mehbubngr	21085	12747	33832	15908	7603	23511	2480	2032	4512	39473	22382	61855
Nalgonda	33693	25659	59352	21628	11680	33308	2210	3205	5415	57531	40544	98075
Warangal	35887	27527	63414	15614	7817	23431	2370	1294	3664	53871	36638	90509
Khammam	20989	19545	40534	12510	5879	18389	1684	1668	3352	35183	27092	62275
Karimnagar	36912	25993	62905	16019	9214	25233	2339	1553	3892	55270	36760	92030
Adilabad	10659	3778	14437	5584	1380	6964	1195	461	1656	17438	5619	23057
Telengana	248318	165968	414286	115625	62293	177918	16021	13493	29514	379964	241754	621718
STATE	561349	513907	1075256	299741	191817	491558	62733	67476	130209	923823	773200	1697023

Table A7.3: AP (1998-99): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	23280	5538	28818	6536	1496	8032	960	1447	2407	30776	8481	39257
Vizianagaram	17776	4921	22697	4927	1040	5967	803	640	1443	23506	6601	30107
Vishakhapatnam	18010	3930	21940	2416	684	3100	646	333	979	21072	4947	26019
East Godavari	41888	49128	91016	11286	16595	27881	3699	10860	14559	56873	76583	133456
West Godavari	35110	58673	93783	20697	31004	51701	7226	15220	22446	63033	104897	167930
Krishna	50475	63027	113502	28324	25519	53843	5946	13127	19073	84745	101673	186418
Guntur	56475	57650	114125	32480	18747	51227	5477	9806	15283	94432	86203	180635
Prakasam	20406	40691	61097	14077	15594	29671	2754	6241	8995	37237	62526	99763
Nellore	13641	39495	53136	6425	15788	22213	1787	5944	7731	21853	61227	83080
Coastal Andhra	277061	323053	600114	127158	126467	253635	29298	63618	92916	433527	513138	946665
Kurnool	34380	30433	64813	30640	14398	45038	6044	5014	11058	71064	49845	120909
Anantapur	13078	13976	27054	11753	5722	17475	2554	2981	5535	27385	22679	50064
Cuddapah	14056	20349	34405	9597	7761	17358	2268	2022	4290	25921	30132	56053
Chittoor	12113	17919	30032	5028	6111	11139	2506	3117	5623	19647	27147	46794
Rayalaseema	73627	82677	156304	57018	33992	91010	13372	13134	26506	144017	129803	273820
Andhra Region	350688	405730	756418	184186	160459	344645	42670	76752	119422	577544	642941	1220485
Ranga Reddy/Hyd	26081	25287	51368	12469	12225	24694	3224	3415	6639	41774	40927	82701
Nizamabad	36637	29255	65892	8964	10219	19183	1552	2516	4068	47153	41990	89143
Medak	21404	15950	37354	6268	7307	13575	979	1668	2647	28651	24925	53576
Mehbubngr	23388	24688	48076	15846	12303	28149	2769	3081	5850	42003	40072	82075
Nalgonda	39205	44020	83225	22979	21137	44116	3187	5356	8543	65371	70513	135884
Warangal	44609	42827	87436	16167	11381	27548	1743	3184	4927	62519	57392	119911
Khammam	24903	27761	52664	14834	7611	22445	1778	2663	4441	41515	38035	79550
Karimnagar	40096	42102	82198	14901	13703	28604	2208	3632	5840	57205	59437	116642
Adilabad	13966	5659	19625	5651	1854	7505	376	440	816	19993	7953	27946
Telengana	270289	257549	527838	118079	97740	215819	17816	25955	43771	406184	381244	787428
STATE	620978	663277	1284255	302265	258198	560463	60484	102709	445808	983727	1024184	2007911

Table A7.4: AP (1999-00): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	22207	6891	29099	6734	2245	8979	3255	742	3998	32196	9878	42076
Vizianagaram	16503	5582	22085	5588	1699	7287	1861	690	2551	23952	7971	31923
Vishakhapatnam	14680	7106	21786	2375	1249	3624	1326	347	1673	18381	8701	27082
East Godavari	42065	56932	98998	12926	20825	33751	9319	10551	19871	64310	88308	152619
West Godavari	46319	71115	117435	27936	37635	65571	10526	14964	25490	84781	123714	208495
Krishna	56449	63733	120182	28692	26231	54923	16509	11330	27839	101650	101294	202944
Guntur	51586	55378	106963	33536	21517	55053	6945	10005	16950	92067	86900	178966
Prakasam	18744	41134	59878	15275	17359	32634	3032	5435	8467	37051	63929	100979
Nellore	14251	37914	52164	5617	15309	20926	2301	4739	7040	22169	57962	80130
Coastal Andhra	282804	345785	628590	138679	144069	282748	55074	58803	113879	476557	548657	1025215
Kurnool	34366	28143	62509	28374	14937	43311	6200	5076	11277	68940	48156	117097
Anantapur	12839	12449	25287	11513	7038	18551	4137	2925	7062	28489	22412	50901
Cuddapah	13822	14972	28793	9737	6770	16507	2198	2703	4901	25757	24445	50202
Chittoor	13271	15347	28619	4694	6047	10741	2847	2899	5746	20812	24293	45106
Rayalaseema	74298	70911	145208	54318	34792	89110	15382	13603	28986	143998	119306	263306
Ranga Reddy/Hyd	29389	19671	49059	15190	10418	25608	5329	4908	10238	49908	34997	84905
Nizamabad	48110	29962	78072	11654	11557	23211	3370	2120	5490	63134	43639	106773
Medak	29247	15080	44327	8682	7379	16061	1902	1433	3335	39831	23892	63723
Mehbubngr	26243	14450	40693	17378	8782	26160	3787	2543	6330	47408	25775	73184
Nalgonda	42740	33485	76225	25823	15257	41080	4929	3442	8371	73492	52184	125676
Warangal	49786	34034	83820	18951	10545	29496	5699	2780	8480	74436	47359	121795
Khammam	29033	23400	52433	15745	8503	24248	3633	2319	5952	48411	34222	82633
Karimnagar	50486	38034	88520	19609	14715	34324	4747	2946	7693	74842	55695	130537
Adilabad	19787	7838	27625	7403	3512	10915	1708	643	2351	28898	11993	40891
Telengana	324821	215954	540774	140435	90668	231103	35104	23134	58240	500360	329756	830117
STATE	681923	632648	1314572	333432	269528	602960	105563	95541	201105	1120918	997718	2118636

Table A7.5: AP (2000-01): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	26078	4209	30287	6705	1833	8538	2825	448	3273	35608	6490	42098
Vizianagaram	17393	3372	20765	5542	853	6395	1721	388	2109	24656	4612	29268
Vishakhapatnam	16968	5624	22592	2934	980	3914	1282	352	1634	21184	6955	28139
East Godavari	37528	60577	98105	13351	24962	38313	7817	11527	19344	58696	97065	155761
West Godavari	43775	74920	118695	27628	35524	63152	9162	11877	21039	80565	122321	202886
Krishna	50913	53538	104451	28739	24429	53168	15476	18941	34417	95128	96909	192037
Guntur	50559	57660	108219	30472	21544	52016	7461	7978	15439	88491	87182	175673
Prakasam	16126	43410	59536	10108	14192	24300	2204	6226	8430	28438	63827	92265
Nellore	10135	39536	49671	5446	14153	19599	2296	4635	6931	17876	58323	76199
Coastal Andhra	269475	342846	612321	130925	138470	269395	50244	62372	112616	450642	543684	994326
Kurnool	41602	35624	77226	31744	18248	49992	7473	7028	14501	80819	60901	141720
Anantapur	15836	17119	32955	11826	7947	19773	5148	3414	8562	32809	38480	71289
Cuddapah	14298	19309	33607	9524	7799	17323	2372	2509	4881	26193	29616	55809
Chittoor	12198	19101	31299	4036	6252	10288	3172	3316	6488	19405	28670	48075
Rayalaseema	83934	91153	175087	57130	40246	97376	18165	16267	34432	159226	147667	306893
Ranga Reddy/Hyd	24034	30589	54623	13275	32648	45923	8333	7464	15797	45642	70700	116342
Nizamabad	44759	27988	72747	9679	9315	18994	3007	2042	5049	57445	39345	96790
Medak	27435	18202	45637	7092	7655	14747	1641	1695	3336	36169	27552	63721
Mehbubngr	29348	18184	47532	17101	9511	26612	3559	2730	6289	50008	30426	80434
Nalgonda	44671	38502	83173	22787	14879	37666	4908	3728	8636	72366	57109	129475
Warangal	49081	38047	87128	16924	9680	26604	4499	2549	7048	70505	50277	120782
Khammam	30696	22848	53544	15481	6633	22114	4913	1972	6885	51090	31453	82543
Karimnagar	55138	48638	103776	19791	15439	35230	3420	3825	7245	78349	67902	146251
Adilabad	20163	6063	26226	6853	1946	8799	1639	346	1985	28655	8355	37010
Telengana	325325	249061	574386	128983	107706	236689	35919	26351	62270	490229	383119	873348
STATE	678733	683060	1361793	317039	286421	603460	104327	104992	209318	1100099	1074472	2174571

Table A7.6: AP (2001-02): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
Srikakulam	20500	7067	27567	5435	2716	8151	2753	737	3490	28688	10520	39208
Vizianagaram	12655	5977	18632	3681	1549	5230	1469	617	2086	17805	8143	25948
Vishakhapatnam	12021	7992	20013	2026	1576	3602	999	3513	4512	15046	13081	28127
East Godavari	25154	54678	79832	8995	32795	41790	8569	16796	25365	42718	104269	146987
West Godavari	27979	68093	96072	17097	36281	53378	9388	12164	21552	54464	116538	171002
Krishna	41555	49195	90750	22229	22581	44810	18593	23560	42153	82377	95336	177713
Guntur	37127	68184	105311	23338	28594	51932	4130	10571	14701	64595	107349	171944
Prakasam	10495	45815	56310	6284	21724	28008	1282	6137	7419	18061	73676	91737
Nellore	7360	42365	49725	4739	16791	21530	1269	4903	6172	13368	64059	77427
Coastal Andhra	194846	349366	544212	93824	164607	258431	48452	78998	127450	337122	592971	930093
Kurnool	25201	42548	67749	20783	22370	43153	5973	8092	14065	51957	73010	124967
Anantapur	13262	20218	33480	12520	9275	21795	4626	7163	11789	30408	36656	67064
Cuddapah	8510	22881	31391	7977	10512	18489	1740	2616	4356	18227	36009	54236
Chittoor	10113	20104	30217	4562	6337	10899	2290	3452	5742	16965	29893	46858
Rayalaseema	57086	105751	162837	45842	48494	94336	14629	21323	35952	117557	175568	293125
Andhra Region	251932	455117	707049	139666	213101	352767	63081	100321	163402	454679	768539	1223218
Ranga Reddy/Hyd	23954	24786	48740	19321	13759	33080	9917	11547	21464	53192	50092	103284
Nizamabad	36022	22751	58773	7532	7605	15137	2620	1624	4244	46174	31980	78154
Medak	17884	16254	34138	5284	6558	11842	1418	1463	2881	24586	24275	48861
Mehbubngr	16054	19028	35082	10989	8899	19888	1720	2759	4479	28763	30686	59449
Nalgonda	26891	41325	68216	14198	15674	29872	2968	3536	6504	44057	60535	104592
Warangal	43267	30760	74027	14041	9701	23742	4961	3125	8086	62269	43586	105855
Khammam	21846	22314	44160	12537	9545	22082	3212	2312	5524	37595	34171	71766
Karimnagar	43708	46090	89798	15569	16525	32094	3520	4175	7695	62797	66790	129587
Adilabad	16463	6271	22734	5798	1533	7331	1915	330	2245	24176	8134	32310
Telengana	246089	229579	475668	105269	89799	195068	32251	30871	63122	383609	350249	733858
STATE	498021	684696	1182717	244935	302900	547835	95332	131192	226524	838288	1118788	1957076

Table B7.1: HP (1996-97): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
bilaspur	1243	703	1946	5	83	88	3	50	53	1251	836	2087
chamba	600	199	799	6	19	25	3	15	18	609	233	842
hamirpur	1703	572	2275	11	76	87	4	38	42	1718	686	2404
kangra	2939	3026	5965	79	889	968	44	458	502	3062	4373	7435
kinnaur	17	53	70	5	18	23	3	20	23	25	91	116
kullu	280	715	995	14	187	201	11	296	307	305	1198	1503
L/spiti	6	95	101	6	44	50	5	36	41	17	175	192
mandi	2244	1855	4099	49	394	443	26	321	347	2319	2570	4889
shimla	859	1444	2303	110	843	953	81	1258	1339	1050	3545	4595
solan	1115	584	1699	41	158	199	20	89	109	1176	831	2007
sirmaur	1500	859	2359	44	163	207	22	76	98	1566	1098	2664
una	1672	1783	3455	90	308	398	36	128	164	1798	2219	4017
State tot	14178	11888	26066	460	3182	3642	258	2785	3043	14896	17855	32751

Table B7.2: HP (1997-98): Season-wise consumption of N, P, K (tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total
bilaspur	1191	778	1969	26	117	143	13	59	72	1230	954	2184
chamba	712	210	922	3	23	26	2	22	24	717	255	972
hamirpur	1582	659	2241	23	100	123	12	51	63	1617	810	2427
kangra	2894	3248	6142	83	1013	1096	46	521	567	3023	4782	7805
kinnaur	31	65	96	3	19	22	3	18	21	37	102	139
Kullu	400	788	1188	31	243	274	24	384	408	455	1415	1870
L/spiti	61	51	112	39	49	88	27	28	55	127	128	255
mandi	2363	1949	4312	106	458	564	55	340	395	2524	2747	5271
shimla	803	1523	2326	111	834	945	74	1278	1352	988	3635	4623
Solan	1044	658	1702	42	206	248	22	118	140	1108	982	2090
sirmaur	1557	978	2535	105	231	336	51	112	163	1713	1321	3034
Una	1589	1868	3457	136	381	517	54	154	208	1779	2403	4182
State tot	14227	12775	27002	708	3674	4382	383	3085	3468	15318	19534	34852

Table B7.3: HP (1998-99): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
bilaspur	1277	705	1982	17	151	168	8	76	84	1302	932	2234
chamba	665	231	896	8	38	46	4	37	41	677	306	983
hamirpur	1773	619	2392	37	116	153	16	55	71	1826	790	2616
kangra	3281	3295	6576	81	1018	1099	39	499	538	3401	4812	8213
kinnaur	24	72	96	2	28	30	2	25	27	28	125	153
Kullu	401	889	1290	36	302	338	28	476	504	465	1667	2132
L/spiti	74	40	114	54	43	97	37	20	57	165	103	268
mandi	2609	2044	4653	104	552	656	55	400	455	2768	2996	5764
shimla	892	1796	2688	141	1237	1378	120	1693	1813	1153	4726	5879
solan	1136	718	1854	57	237	294	30	131	161	1223	1086	2309
sirmaur	1644	1022	2666	129	269	398	63	137	200	1836	1428	3264
Una	1948	1985	3933	144	418	562	68	179	247	2160	2582	4742
State tot	15724	13416	29140	810	4409	5219	470	3728	4198	17004	21553	38557

Table B7.4: HP (1999-00): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
bilaspur	1188	721	1909	51	178	229	25	89	114	1264	988	2252
chamba	689	220	909	11	35	46	7	28	35	707	283	990
hamirpur	1641	531	2172	83	124	207	36	59	95	1760	714	2474
Kangra	3129	3189	6318	326	1153	1479	156	603	759	3611	4945	8556
kinnaur	24	69	93	4	28	32	2	29	31	30	126	156
Kullu	360	686	1046	47	169	216	36	261	297	443	1116	1559
L/spiti	106	16	122	88	7	95	54	5	59	248	28	276
Mandi	2240	1929	4169	146	623	769	75	392	467	2461	2944	5405
Shimla	715	1576	2291	127	946	1073	91	1293	1384	933	3815	4748
Solan	1101	701	1802	69	282	351	33	151	184	1203	1134	2337
sirmaur	1669	963	2632	170	348	518	86	163	249	1925	1474	3399
Una	2050	2080	4130	261	486	747	110	204	314	2421	2770	5191
State tot	14912	12681	27593	1383	4379	5762	711	3277	3988	17006	20337	37343

Table B7.5: HP (2000-01): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
bilaspur	1124	331	1455	31	199	230	15	101	116	1170	631	1801
chamba	772	85	857	14	33	47	7	24	31	793	142	935
hamirpur	1619	212	1831	89	175	264	44	88	132	1752	475	2227
kangra	3270	2015	5285	142	1493	1635	72	699	771	3484	4207	7691
kinnaur	18	42	60	2	14	16	3	15	18	23	71	94
kullu	380	663	1043	54	227	281	36	298	334	470	1188	1658
L/spiti	63	37	100	52	24	76	34	15	49	149	76	225
mandi	2357	992	3349	149	663	812	74	390	464	2580	2045	4625
shimla	875	1629	2504	202	1239	1441	130	1708	1838	1207	4576	5783
solan	1216	620	1836	92	281	373	43	144	187	1351	1045	2396
sirmaur	1669	829	2498	179	351	530	90	180	270	1938	1360	3298
una	1982	1618	3600	263	572	835	130	254	384	2375	2444	4819
State tot	15345	9073	24418	1269	5271	6540	678	3916	4594	17292	18260	35552

Table B7.6: HP (2001-02): Season-wise consumption of N, P, K (in tonnes)

	Nitrogen (N)			Phosphate (P_2O_5)			Potash (K_2O)			($N+P_2O_5+K_2O$)		
District	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**	**Kharif**	**Rabi**	**Total**
bilaspur	1031	622	1653	33	185	218	16	93	109	1080	900	1980
chamba	800	217	1017	16	48	64	8	40	48	824	305	1129
hamirpur	1306	553	1859	65	164	229	34	81	115	1405	798	2203
kangra	2576	3056	5632	116	1410	1526	55	690	745	2747	5156	7903
kinnaur	20	48	68	5	16	21	3	24	27	28	88	116
kullu	518	902	1420	79	401	480	55	522	577	652	1825	2477
L/spiti	66	28	94	57	21	78	36	10	46	159	59	218
mandi	2351	2020	4371	161	768	929	82	465	547	2594	3253	5847
shimla	1024	2127	3151	171	1546	1717	151	2367	2518	1346	6040	7386
solan	1796	832	2628	220	301	521	113	156	269	2129	1289	3418
sirmaur	1209	689	1898	103	285	388	49	149	198	1361	1123	2484
una	1733	1979	3712	278	594	872	128	283	411	2139	2856	4995
State tot	14430	13073	27503	1304	5739	7043	730	4880	5610	16464	23692	40156

TableA7. 2.1: District wise consumption of pesticide in AP (technical grade) from 1994-95-2002-03

District	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Srikakulam	74	102	40	13	16	23	18	45	14
Vizianagaram	148	107	107	47	50	57	44	37	32
Vishakhapatnam	178	124	94	83	2	2	27	25	61
East Godavari	288	447	310	550	197	167	257	255	140
West Godavari	1020	968	543	280	143	124	204	250	170.72
Krishna	624	552	533	446	127	65	186	260	350
Guntur	2727	2807	2578	2240	316	683	391	380	515
Prakasam	364	156	316	128	358	80	215	203	190
Nellore	142	267	234	191	567	210	288	212	210
Kurnool	343	602	350	414	612	483	378	322	180
Anantapur	248	204	178	75	143	63	124	84	100
Cuddapah	150	118	138	80	99	202	87	60	105
Chittoor	250	711	251	77	79	65	66	67	76
Ranga Reddy/Hyd	285	435	214	329	245	98	186	210	90
Nizamabad	607	475	304	172	118	70	120	132	45
Medak	65	78	81	51	89	108	85	105	45
Mehbubngr	258	187	258	154	187	118	175	155	105
Nalgonda	230	412	205	306	212	106	205	380	170
Warangal	594	837	802	783	323	246	294	310	270
Khammam	272	440	482	353	644	812	375	148	210
Karimnagar	282	728	395	236	129	190	142	150	210
Adilabad	185	200	289	290	85	82	133	110	112
TOTAL	9334	10957	8702	7298	4741	4054	4000	3900	3400.7

Table A7.2.2: District wise pesticides of HP during 2003-04 (kgs/hect)

District	Kgs/Hect.
Bilaspur	11775
Chamba	9090
Hamipur	15305
Kangra	34225
Kinnaur	8315
Kullu	12125
Mandi	21065
Shimla	12466
Keylong	17720
Solan	8791
Una	7710
Nahan	4617
Total	163204

Source: Dept of Agriculture HP

General Appendices

A1. Andhra Pradesh Water Quality, 2003

Table A1.1: Chemical Constituents in River Krishna, 2003 (avg. values)

RIVER/ TRIBUTARY	LOCATION	Temp	Ph	Cond	DO	BOD	COD	Faecal Col.	Tot Col.	Nitrite	Nitrate
KRISHNA	THANGADI , MAHABOOBNAGAR DIST., A.P	25	8.2	550	8.3	1.8	-	225	494	-	-
KRISHNA	KRISHNA AT GADWAL BRIDGE, A.P.	26	8.1	531	8.1	2.2	-	180	205	-	0.400
KRISHNA	KRISHNA AFTER CONFL. WITH TUNGABHADRA, SANGAMESHWARAM A.P.	30	8.3	613	6.1	1.9	10.5	-	-	-	0.360
KRISHNA	KRISHNA AT WADAPALLY AFTER CONFL. WITH R. MUSI, A.P.(SHIFTED FROM 1220)	26	7.5	537	6.1	3.0	68.0	17000	60000	-	0.240
KRISHNA	VEDADRI , GUNTUR DIST., A.P	29	8.2	613	7.5	1.4	16.0	3	1533	-	0.099
KRISHNA	AMARAVATI , GUNTUR DIST., A.P	26	8.0	616	6.5	1.3	16.0	3	2400	-	1.192
KRISHNA	KRISHNA AT VIJAYWADA, A.P.	29	8.2	570	7.0	1.6	12.0	3	2075	-	0.070
KRISHNA	HAMSALA DEEVI , GUNTUR DIST, A.P	29	8.0	18888	4.7	2.5	64.0	3	615	-	0.590
TUNGHABHADRA	MANTHRALAYAM , KURNOOL DIST., A.P	31	8.4	624	6.2	2.1	13.2	-	-	-	0.460
TUNGHABHADRA	TUNGHABHADRA AT KURNOOL U/S, BAVAPURAM, A.P.	31	8.3	640	6.1	2.2	13.6	-	-	-	0.460

Table A1.2: Chemical Constituents in River Godavari, 2003 (avg. values)

RIVER/ TRIBUTARY	**LOCATION**	**Temp**	**pH**	**Cond.**	**DO**	**BOD**	**COD**	**Faecal Col.**	**Nitrite**	**Nitrate**
GODAVARI	GODAVARI AT MANCHERIAL, A.P.	28	8.3	488	8.4	3.2	5.0	-	-	0.650
GODAVARI	GODAVARI AT POLAVARAM, A.P.	27	7.9	198	7.2	-	5.0	284	-	0.665
GODAVARI	GODAVARI AT RAJAHMUNDRY U/S, A.P.	26	8.0	227	6.0	-	-	-	-	0.121
GODAVARI	GODAVARI AT RAJAHMUNDRY	30	8.2	219	7.7	7.2	-	794	-	0.170
MANJEERA	MANJERA AT RAIPALLU, A.P.	25	7.5	387	6.2	2.5	16.0	-	-	0.248
MANJEERA	MANJEERA RIVER, MEDAK DIST.,	25	7.5	343	6.3	2.9	-	-	-	-
MANER	MANER AT WARANGAL U/S, A.P.	29	8.2	431	6.0	2.5	-	8	0.018	0.487
MANER	MANER AT SOMNAPALLI, A.P.	27	7.9	442	8.2	2.4	-	-	-	-

Table A1.3: Chemical Constituents in River Pennar, 2003 (avg. values)

RIVER	LOCATION	Temp. AVG	pH	Elec. Cond.	DO	BOD	COD	Faecal Col.	Nitrate
PENNER	PENNER BEFORE CONFL.WITH CHITRAVATHI,TADPATRI,UNGANOOR,A.P.	26	8.3	979	6.0	3.6	15.6	2	0.440
PENNER	PENNER AFTER CONF. WITH PAPAGNI,PUSPAGINI,A.P.	27	8.4	737	6.0	3.6	15.4	2	0.500
PENNER	PENNER AFTER CONF. WITH CHEYYURU,SOMASILE,A.P.	27	8.0	559	6.9	1.5	16.0	3	2.420
PENNER	PENNER AT SIDDVATA, NELLORE, A.P.	26	8.3	823	6.0	2.3	15.0	-	0.480

Table A1.4: Chemical Constituents in Lakes and Tanks, 2003 (avg. values)

LAKE / POND / TANK / CREEK	LOCATION	Temp	pH	Elec Cond.	DO	BOD	COD	Faecal Col.	Nitrate	Amm. Nit.
HUSSAIN SAGAR	HUSSAIN SAGAR LAKE, BUDAMERU, A.P.	27	7.9	1343	5.4	3.9	-	-	2.600	-
SAROORNAGAR	SAROONAGAR, RANGA REDDY DIST., A.P	28	8.3	2233	3.6	16.3	165.0	190	8.500	-
HIMAYAT SAGAR	HIMAYAT SAGAR LAKE, R.R.DIST., A.P	27	8.2	700	7.4	1.9	-	-	-	-
PULICATE	PULICATE LAKE, NELLORE DIST., A.P	27	8.1	30710	4.5	5.8	-	3	-	-
BIBINAGAR TANK	BIBINAGAR TANK, A.P.	27	8.4	1014	6.7	20.3	140.0	14000	6.400	-
KISTARADDY	KISTAREDDYPET TANK, MEDAK DIST., A.P	24	8.0	3684	4.3	91.0	260.0	14200	10.400	-

Table A1.5: Chemical Constituents in Wells, 2003 (avg. values)

LOCATION	Temp	pH	Elec.Cond.	BOD	COD	Faecal Col.	Nitrite	Nitrate	Amm. Nit.
Kuyyura	29	7.8	178	0.4	6	-	-	-	-
Tadavai	27	8.1	730	1.2	6	-	-	2.5	-
Vijaywada	31	7.8	558	5.7	-	3	-	-	-
Peddavoora	30	7.5	1634	1	-	-	-	-	-
East Of Saicheruvu (V),Warangal	29	8	577	1.7	12	-	-	0.5	-
Near CKM College, Warangal	28	7.8	1280	0.9	10	-	-	9.5	-
Bhoomaiah, Near Ashponds Of NTPC, Karimnagar	29	8.2	1748	3.2	8	-	-	8.5	-
Manakondur (V), Karimnagar	30	8	880	1.3	10	-	-	0.9	-
Panchayat Office, Medak	30	7.1	3610	1.1	12	-	-	4.8	-
IDA, Near Chaitanya Chlorides, Medak	28	7.1	2418	1.2	-	-	-	12.2	-
Sri Ramnagar Colony, Sakkar Nagar, Nizamabad	29	7.5	980	0.9	6	-	-	3.8	-
Primary School - Rudravelli (V) , Nalgonda Dist.	30	7.8	2026	2.8	14	-	-	2.3	-
Krishna Murthy, D NO. 48-16 -43 Autonagar, Krisna	25	7.8	1268	2	-	3	-	-	-
Vijay Kumar Autonagar KRISHNA DIST.	31	7.7	1153	1	12	3	-	5.72	-
Nagaram(V) , Khammam	28	7.3	2760	1.2	-	3	-	-	-
Navlok Gardens, ,Nellore,	32	7.8	1465	1.7	12	3	-	5.4	-
Tungbhadra River Near Kurnool	31	8.5	944	3.4	-	-	-	-	-
Nandyal , Kurnool	31	8.4	996	3.6	-	-	-	-	-
Nagiri , Chittoor	24	8.2	852	3	-	-	-	-	-
Swarnamukhi river, Srikalahasti , Chittoor	28	8.4	955	3	15.4	-	-	0.46	-
Near Rama Temple, Visakhapatnam	30	8.5	4270	-	-	80	-	-	-
Peddanuyyi - Vizianagaram	28	8.3	1263	-	-	-	-	13	-
Near M/S Andhra Sugars LTD. , Kovvur , W.G.Dist	25	8.1	204	-	2	-	-	0.05	-
Near Partap Nagar Bridge -Kakinada , E.G.Dist	27	7.5	1209	-	8	-	-	0.92	-

A2. Andhra Pradesh Water Quality, 2000

Table A2.1: Chemical Constituents in River Godavari (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Mancherial	7.5	1.9	11	0.81	8.2	493	28.9	24.6	18.7	197	158	314
2	Polavaram	6.9	4.6	19.5	0.65	8.2	229	25.6	22.6	9.5	161	104	151
3	Rajahmundry U/S	7	5.6	20	0.2	8.2	213	2.8	23.7	8.9	102	100	143
4	Rajahmundry D/S	7.2	6	22	0.37	8.3	286	28	30	9.9	110	101	176
5	Raipally	6.4	2.4	9.7	-	7.6	279	26.3	26	17.8	136	146	180
6	Shivampet	6.3	2.6	12	0.4	7.9	410	-	19.6	14.6	141	154	200
7	Somanpally	7.1	2.6	13.2	0.41	7.4	547	28	41	21	190	162	290

Table A2.2: Chemical Constituents in River Krishna (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	**Thangadi**	-	2.8	13	1.2	8.8	690	-	62	51	410	210	410
2	Gadwal	7.6	2.2	14.3	1.39	8.3	741	30	60	33	206	210	441
3	Srisailam	6.5	3.3	16.3	0.36	7.6	565	30	81	43	178	156	380
4	Wadapally	6.5	2.3	8.8	0.32	8.1	434	26	38	28	167	213	295
5	Vedadri	8	1.9	16	0.5	8.2	589	30.5	60	39	215	152	370
6	Amaravathi	7.9	2	24	0.7	8.2	682	29.5	70	31	300	140	430
7	Vijayawada	7.2	2.5	12.6	0.39	8.3	550	27.8	59	32	172	150	353
8	Hamsaladeevi	7.3	2.6	34	0.02	8	3307	30	1014	99	223	420	2175
9	Keesara	8.5	2.1	16	0.4	7.6	647	29	70	24	229	163	381
10	Jaggaiahpet	7.4	2.3	18.6	0.81	8.4	580	29	54	45	188	226	365
11	Musi D/S	-	25	118	9.6	7.9	1893	31.5	276	133	460	472	1199
12	Manthralayam	-	2.8	16	0.63	8.2	612	26.5	57	41	208	159	356
13	Bavapuram	7.1	3	17	0.88	7.9	629	27	76	50	199	167	435

Table A2.3: Chemical Constituents in River Pennar (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Unganoor	6.9	3.5	22	0.85	7.9	921	30	110	39	250	160	527
2	Pushpagiri	6.6	3.2	19	0.43	6.8	719	28	88	37	181	176	497
3	Siddavatam	6.7	3.4	20	0.78	7.8	780	29	110	35	142	188	531
4	Somasila	7.8	2.3	15	0.59	8.8	554	31.5	93	35	144	120	370

Table A2.4: Chemical Constituents in River Nagavelli (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Thotapalli	5.5	2.6	20.5	-	7.3	346	7.3	22	6.7	107	122	222

Table A2.5: Chemical Constituents in lakes and tanks (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Tummala Cheruvu	7.3	2.3	10	1.4	7.8	676	26.6	39	15	282	206	423
2	Dharmasagar Tank	8.5	4.2	24	1.2	7.9	543	29	40	17	161	153	354
3	Bibinagar tank	6.2	3.5	22	1.66	8.4	518	26	64	52	421	217	306
4	Hussain Sagar lake	8.6	15.3	46	3.2	8.8	1196	29	152	77	407	283	578
5	Himayatsagar lake	-	-	9	0.6	8.5	450	-	70	BDL	270	170	258
6	Saroornagar lake	-	6	21	7.3	8.6	1290	-	120	74	340	270	700
7	Pulicat Lake	4	7.3	92	0.168	8	37900	-	1354	799	160	4100	25300

Table A2.5: Ground water quality including open and bore wells (avg. values)

S.No.	Location	BOD	COD	Nitrates	pH	EC	Cl-	SO4-	TA	TH	TDS
1	**Bodhan**		NIL	3.3	7.6	810	48	82	345	153	180
2	Rudravelly		NIL	2.82	8.2	1890	420	130	405	874	1445
3	Bollaram		NIL	15.5	7	2250	567	160	200	1395	1610
4	Peddavoora		NIL	2.5	7.8	2170	321	75	513	380	1270
5	Pashamylaram		NIL	2.4	7.5	1080	240	217	210	510	905
6	Autonagar Vijayavada	4	40	1.9	7.5	975	125	50	315	110	620
7	Bore well at Autonagar Vijayawada	4.2	40	2.1	7.7	1295	160	101	330	42	840
8	Nellore	4	36	0.4	7	1958	400	94	470	406	1250
9	Nagaram	4.2	44	8.1	7.3	2080	245	142	515	434	1360
10	Kovvur		8		8	250	10	5	112	92	154
11	Tadavai	2	10		6.9	1030	106	36	204	383	758

A3. Andhra Pradesh Water Quality, 2001

Table A3.1: Chemical Constituents in River Godavari (avg. values)

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Mancherial	8.5	2.7	16	0.3	8.3	507	28	28	21	210	201	360
2	Polavaram	6.8	5.1	25	6.4	8	388	26	34	6.7	103	120	394
3	Rajahmundry U/S	6.7	4	19	6.5	7.6	578	27	23	20	100	106	300
4	Rajahmundry D/S	6.8	5.5	24	6.7	7.9	588	28	38	20	128	108	436
5	Raipally	5.7	2	11	0.6	7.9	294	25	36	16	139	120	194
6	Shivampet	6.2	2.5	12	0.5	8	286	25	52	16	147	153	223
7	Somanpally	8.3	3.4	20	0.4	8.4	536	28	40	24	218	172	352

A3.2: Water quality statistics of River Krishna

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Thangadi	7.7	3.7	13.5	0.45	8.5	856	26	150	75	185	250	500
2	Gadwal	7.9	2.2	21	0.8	8.3	640	25	150	75	140	275	415
3	Srisailam	6.4	2.3	15	0.3	8	556	27	65	48	170	150	350
4	Wadapally	5.6	2.4	14	0.7	7.4	559	25	60	50	153	163	350
5	Vedadri	7.9	1.3	16	0.3	8.1	523	24	51	48	180	170	355
6	Amaravathi	7.9	1.6	16	0.03	8	598	29	50	45	175	122	385
7	Vijayawada	8	1.1	12	0.1	8.2	519	24	47	45	160	100	335
8	Hamsaladeevi	5.9	4.3	43	0.18	8.1	7544	27	2650	350	300	1100	5151
9	Keesara	8	1.6	18	0.07	8.2	748	28	93	47	260	145	550
10	Jaggaiahpet	8.6	1.8	20	0.16	8.1	729	28	100	52	270	195	515
11	Musi D/S	5.3	24	75	19	7.8	1769	30	290	97	512	482	1200
12	Manthralayam	6.3	2.5	15	0.72	8.2	608	27	61	39	199	159	332
13	Bavapuram	6.4	2.5	15	0.74	8.2	585	27	48	43	211	156	359

Table A3.3: Water quality statistics of River Pennar

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Unganoor	6.4	3	12	0.6	8	960	28	85	47	215	120	545
2	Pushpagiri	6.4	3.1	17	0.3	7.9	683	28	86	43	170	171	395
3	Siddavatam	6.4	2.8	19	0.7	7.7	758	28	115	51	116	173	438
4	Somasila	7.5	1.5	12	0.07	8.5	519	28	60	29	160	64	230

Table A3.4: Water quality statistics at River Nagavali

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Temp	Cl-	SO4-	TA	TH	TDS
1	Thotapalli	6.1	5.5	26	7.8	7.7	410	28	32	260	131	118	396

Table A3.5: Water quality at Lakes and Tanks

S.No.	Location	DO	BOD	COD	Nitrates	pH	EC	Cl-	SO4-	TA	TH	TDS
1	**Tummala Cheruvu**	8	2.2	9	-	7.8	730	446	19	404	310	563
2	**Dharmasagar Tank**	10	5.2	37	-	7.8	411	23	17	162	140	244
3	**Bibinagar tank**	5.9	6.8	40	8.9	8	600	500	99	227	152	500
4	**Hussain Sagar lake**	4.5	10	40	6.7	8	1400	464	97	252	356	821
5	**Himayatsagar lake**	8.1	4	19	0.9	8.4	300	15	6	161	140	174
6	**Saroornagar lake**	3.8	10	43	27	8.5	2200	346	53	830	500	1460
7	**Pulicat Lake**	3	28	120	BDL	7.5	235100	81500	620	360	34600	255010
8	**Osmansagar**	6.6	3.1	13	0.7	8.3	292	43	3	230	200	260
9	**Gandgudem** Tank	2.5	5	20	3.1	7.4	1910	196	108	170	180	1136
10	**Kistareddypet** Tank	3.5	12	29	15.3	7.2	1383	433	124	300	460	800

B. Himachal Pradesh Water Quality

Table B1.1: Chemical Constituents in rivers, 2003(avg. values)

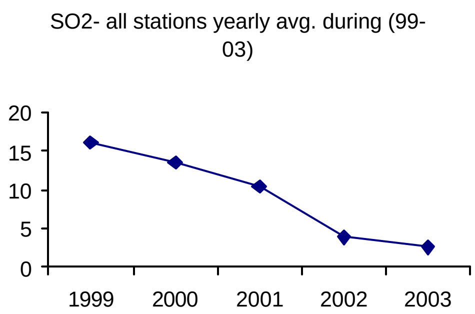
RIVER/ TRIBUTARY	LOCATION	Temp.	pH	Elec. Cond.	DO	BOD	COD	Faecal Col.	Nitrite	Nitrate
BEAS	BEAS AT U/S MANALI, H.P.	6	8.1	116	10.0	0.3	5.0	135	-	-
BEAS	BEAS AT D/S KULU, H.P.	10	8.0	166	9.1	0.7	5.0	283	-	-
BEAS	BEAS AT D/S AUT, H.P.	7	8.0	141	10.1	0.9	6.0	82	-	-
BEAS	BEAS AT U/S PANDON DAM, H.P.	8	8.2	161	9.8	0.6	7.0	20	-	-
BEAS	BEAS AT EXIT OF TUNNEL DEHAL POWER HOUSE, H.P.	8	8.0	140	10.8	1.3	1.0	29	-	-
BEAS	U/S MANDI, H.P	9	8.1	203	9.3	1.1	6.0	25	-	-
BEAS	BEAS AT D/S MANDI, H.P.	10	8.0	250	8.2	1.2	18.0	421	-	-
BEAS	BEAS AT D/S ALAMPUR, H.P.	17	8.1	293	8.1	0.8	3.0	10	-	-
BEAS	BEAS AT D/S DEHRAGOPIPUR, H.P.	19	8.1	258	7.7	1.0	3.0	26	-	-
BEAS	BEAS AT D/S PONG DAM, H.P.	24	8.1	240	8.3	0.7	2.0	6	-	-
SATLUJ	SATLUJ AT NEPTHA ZAKHAI, H.P	14	8.3	289	9.5	0.3	6.0	7	0.060	0.120
SATLUJ	SATLUJ AT U/S RAMPUR, H.P.	13	8.1	272	9.4	0.1	9.2	152	-	-
SATLUJ	SATLUJ AT D/S RAMPUR, H.P.	14	8.2	267	9.4	0.2	8.0	226	-	-
SATLUJ	SATLUJ AT U/S TATAPANI, H.P.	15	8.2	530	9.2	0.2	10.0	104	-	-
SATLUJ	SATLUJ AT U/S SLAPPER, H.P.	10	8.4	337	9.5	0.8	3.0	38	-	-
SATLUJ	SATLUJ AT D/S SLAPPER, H.P.	9	8.3	283	10.2	0.9	4.2	41	-	-
SATLUJ	SATLUJ AT D/S BHAKHRA, H.P.	16	8.3	205	9.2	0.4	8.0	2	-	-

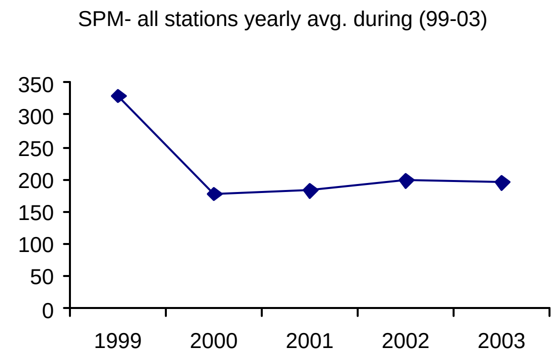
Table B1.2: Chemical Constituents in wells, 2003(avg. values)

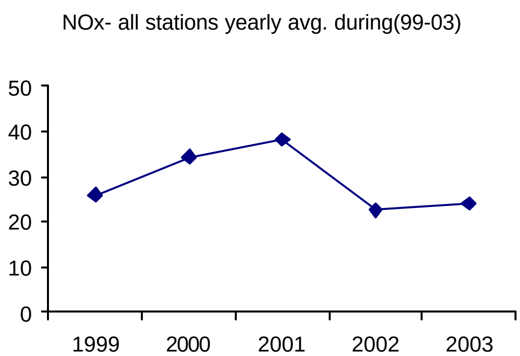
LOCATION	Temp	pH	Elec Cond.	BOD	COD	Faecal Col.	Nitrite	Nitrate	Amm. Nit
AT KALA AMB, H.P	20	8.7	896	5.3	36	45	-	-	-
AT PAONTA SAHIB, H.P	21	8.2	666	4.3	28	37	-	-	-
AT PARWANOO, H.P	25	7.4	706	0.1	15	-	-	-	-
AT BADDI, H.P	26	7.6	526	0.1	4	-	-	-	-
AT BAROTIWALA, H.P	26	7.7	564	2.8	-	3	-	-	-
AT NALAGARH, H.P	25	7.6	1049	0.1	7	8	-	-	-
AT DAMTAL, H.P	27	7.5	656	0.8	4	-	-	-	-
AT UNA, H.P	26	8.2	1124	0.1	9	16	-	-	-

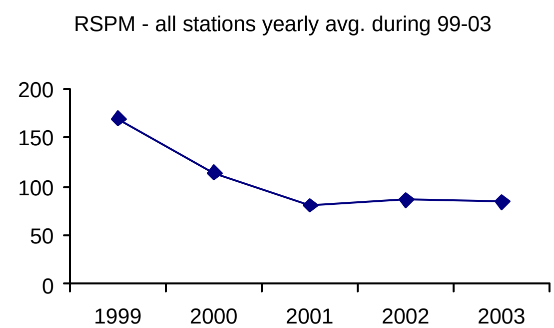
C. Physical Accounts of Ambient Air Quality: Andhra Pradesh

SPM, RSPM, NOx, SO2 of all stations (Hyderabad) annual averages during 1999-2003



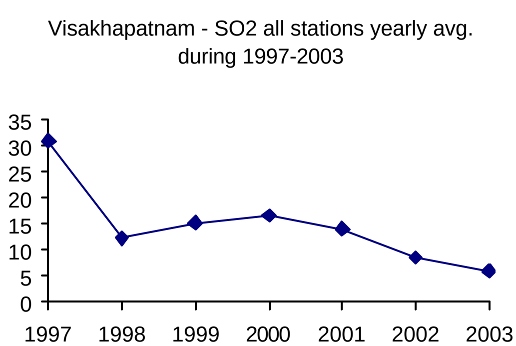


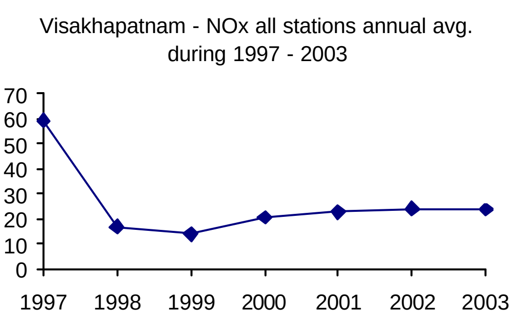


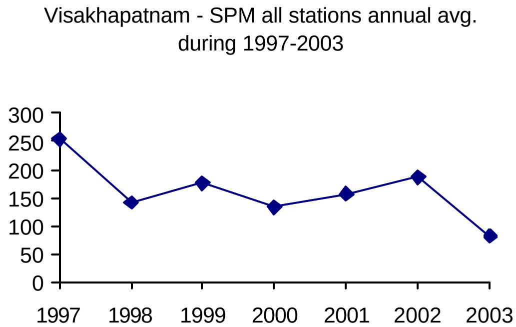


*Annual Averages taken from 4(Balanagar, Uppal, Banjarahills, Jublihills) monitoring stations, which were reported by Pollution Control board

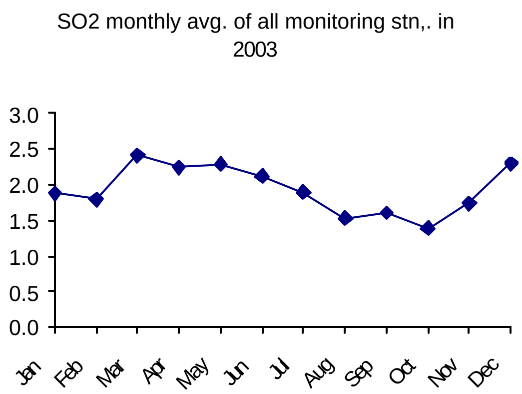
SPM, RSPM, Nox, SO2 of all stations (Visakhapatnam) annual averages during 1999-2003

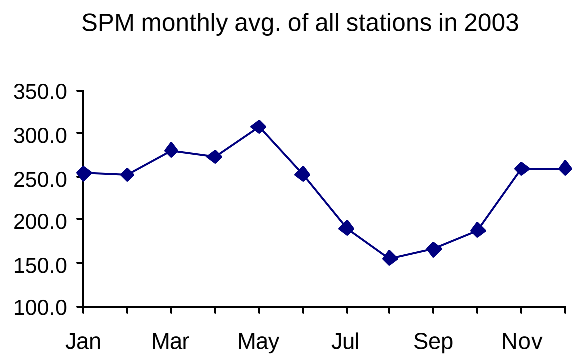


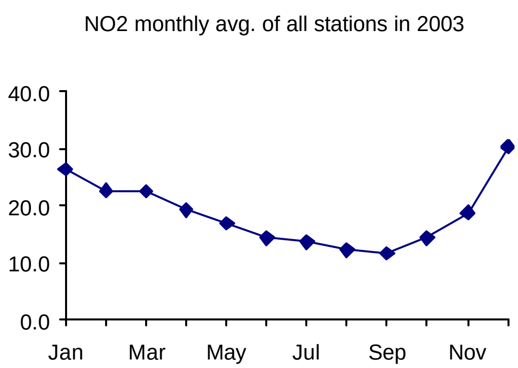




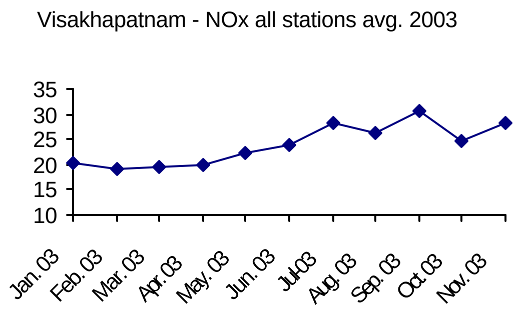
SPM, RSPM, Nox, SO2 of all stations (Hyderabad) monthly averages during 2003.

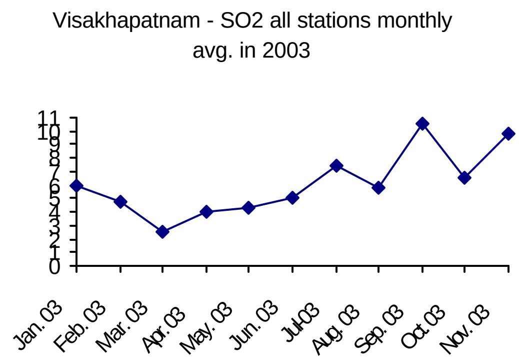


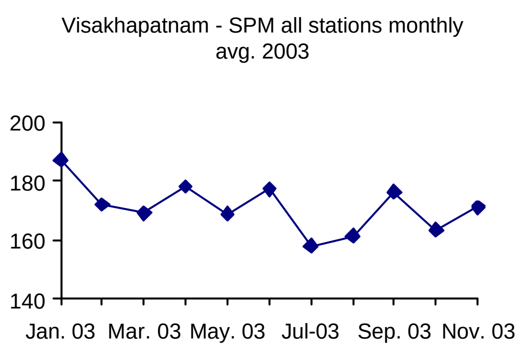


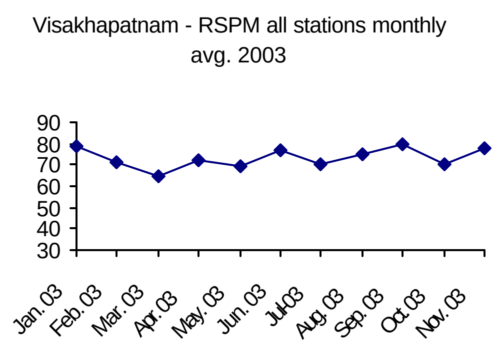


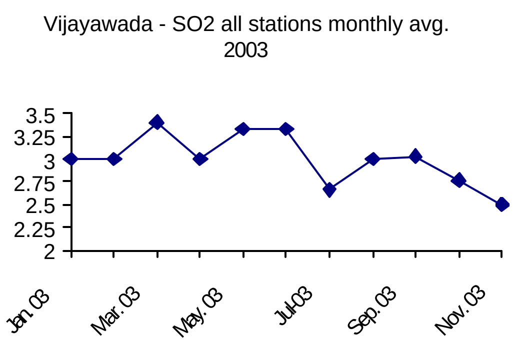
SPM, RSPM, Nox, SO2 of all stations of major cities in AP monthly averages during 2003

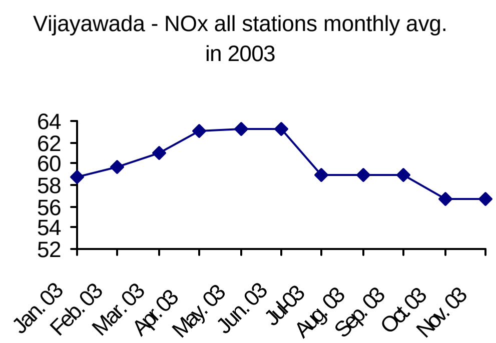


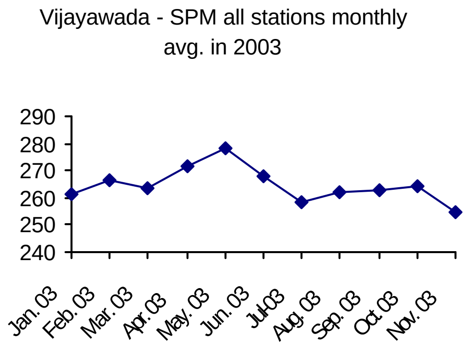


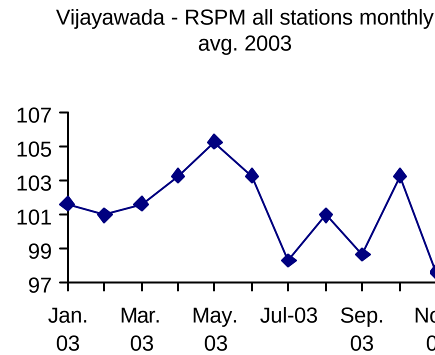


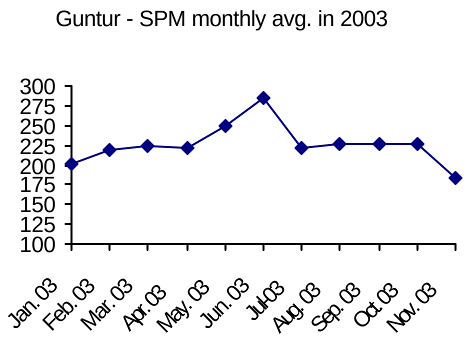


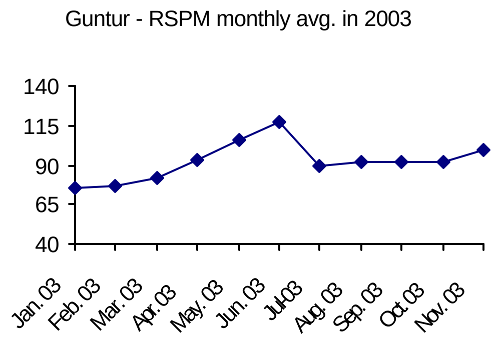


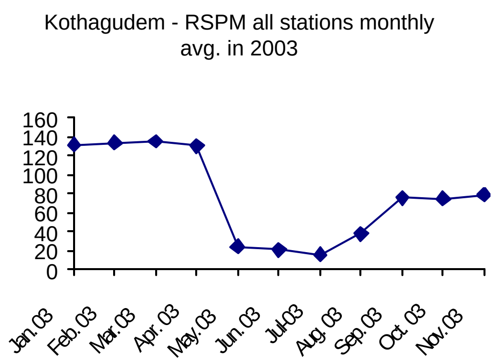


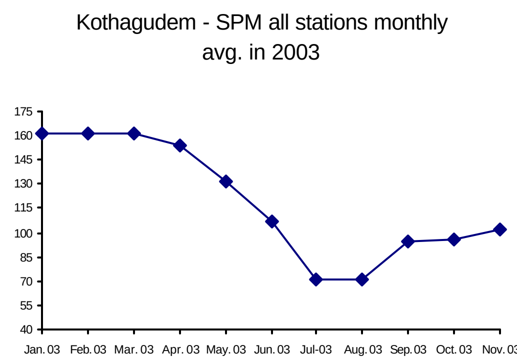

Vijayawada - SPM all stations monthly avg. in 2003
290
280
270
260
250
240
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

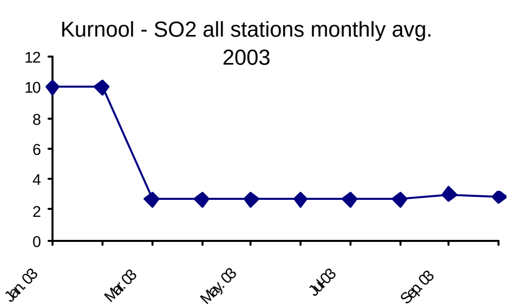

Vijayawada - RSPM all stations monthly avg. 2003
107
105
103
101
99
97
Jan. 03
Mar. 03
May. 03
Jul-03
Sep. 03
Nov. 03

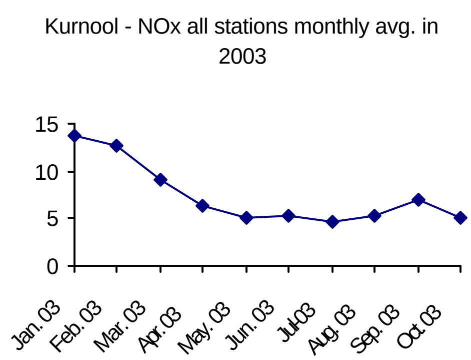

Guntur - SPM monthly avg. in 2003
300
275
250
225
200
175
150
125
100
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

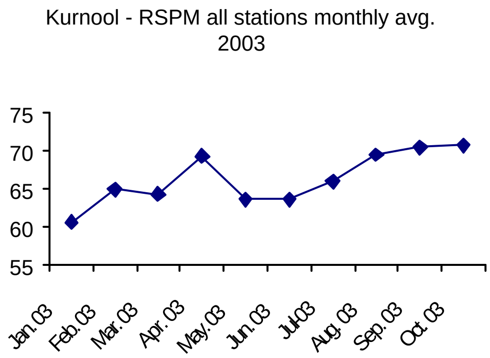

Guntur - RSPM monthly avg. in 2003
140
115
90
65
40
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

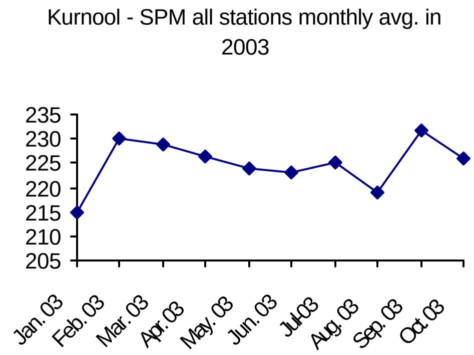

Kothagudem - RSPM all stations monthly avg. in 2003
160
140
120
100
80
60
40
20
0
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

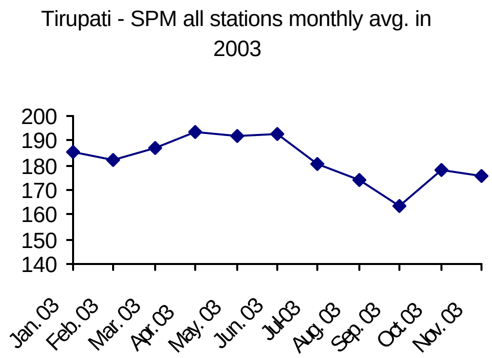

Kothagudem - SPM all stations monthly avg. in 2003
175
160
145
130
115
100
85
70
55
40
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

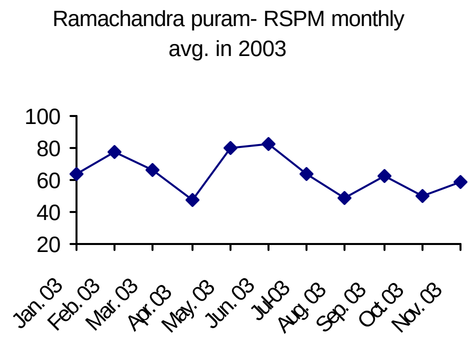

Kurnool - SO2 all stations monthly avg. 2003
12
10
8
6
4
2
0
Jan. 03
Mar. 03
May. 03
Jul-03
Sep. 03

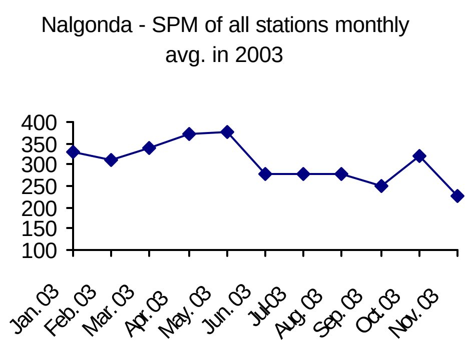

Kurnool - NOx all stations monthly avg. in 2003
15
10
5
0
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03

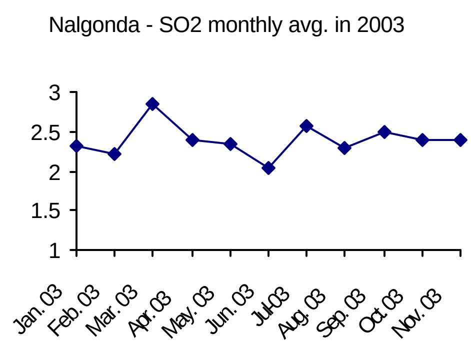

Kurnool - RSPM all stations monthly avg. 2003
75
70
65
60
55
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03

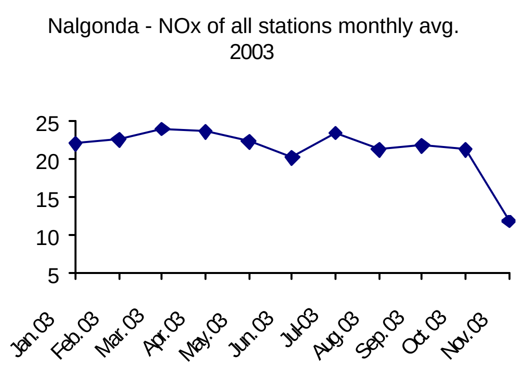

Kurnool - SPM all stations monthly avg. in 2003
235
230
225
220
215
210
205
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03


Tirupati - SPM all stations monthly avg. in 2003
200
190
180
170
160
150
140
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03


Ramachandra puram- RSPM monthly avg. in 2003
100
80
60
40
20
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

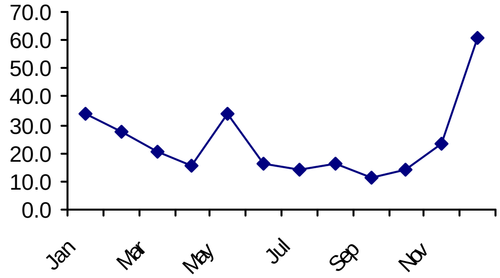

Nalgonda - SPM of all stations monthly avg. in 2003
400
350
300
250
200
150
100
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03


Nalgonda - SO2 monthly avg. in 2003
3
2.5
2
1.5
1
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

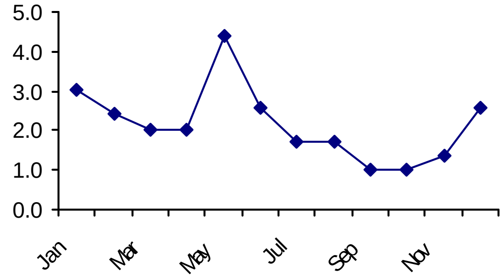

Nalgonda - NOx of all stations monthly avg. 2003
25
20
15
10
5
Jan. 03
Feb. 03
Mar. 03
Apr. 03
May. 03
Jun. 03
Jul-03
Aug. 03
Sep. 03
Oct. 03
Nov. 03

SPM, RSPM, Nox, SO2 station wise (Hyderabad) monthly averages in 2003

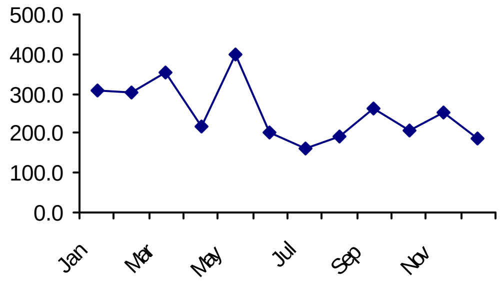
Balanagar- NO2 monthly avg. in 2003



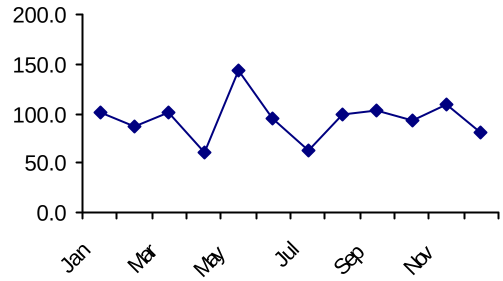
Balanagar - SO2 monthly avg. in 2003



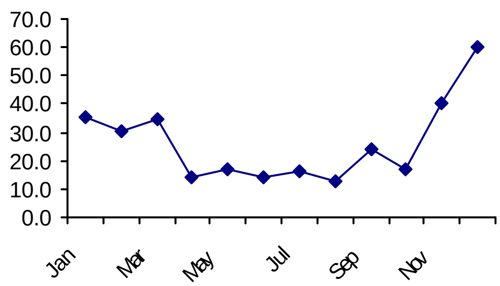
Balanagar - SPM monthly avg. in 2003



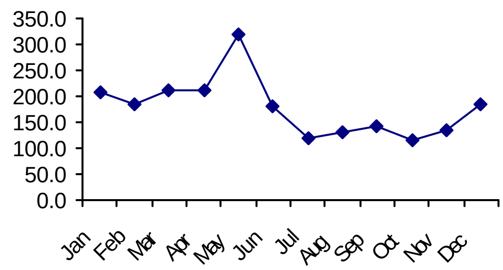
Balanagar - RSPM monthly avg. in 2003



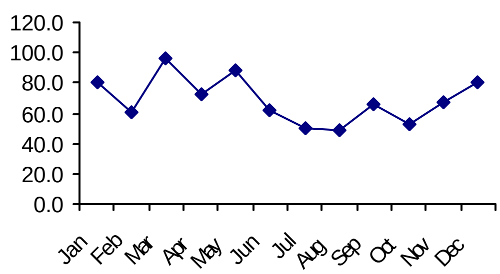
Uppal - NO2 monthly avg. in 2003



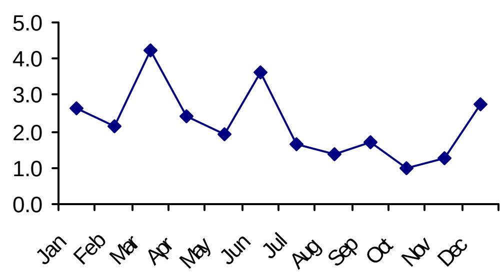
Uppal - SPM monthly avg. in 2003

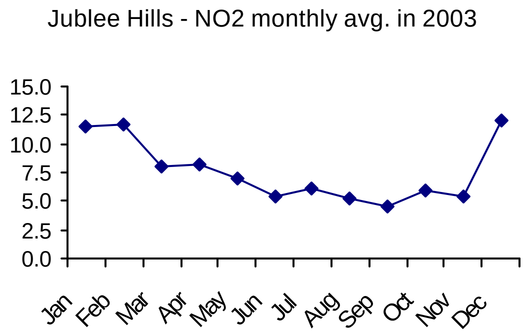


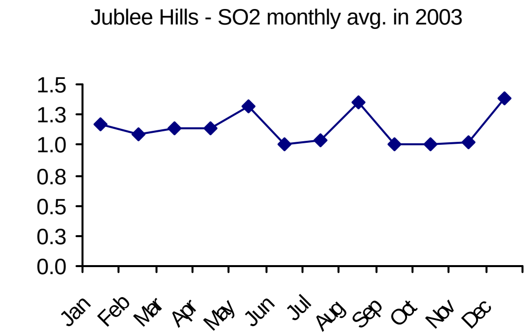
Uppal - RSPM monthly avg. in 2003

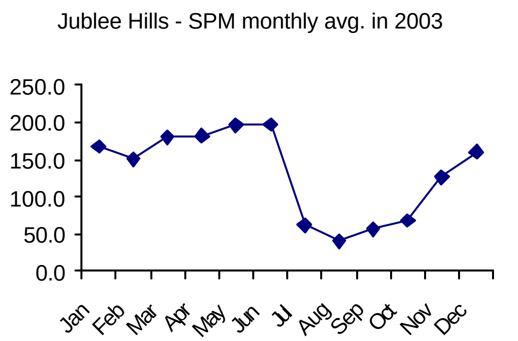


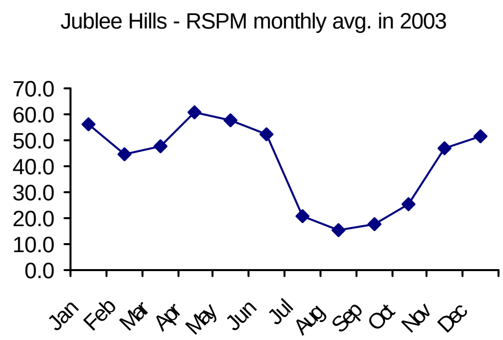
Uppal - SO2 monthly avg. in 2003

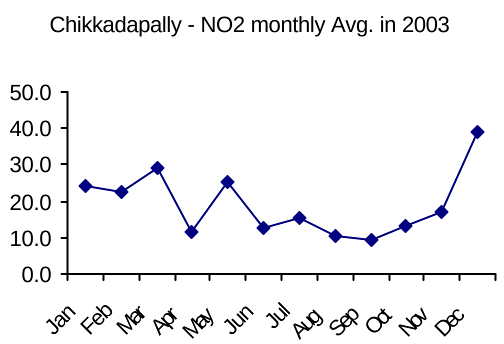


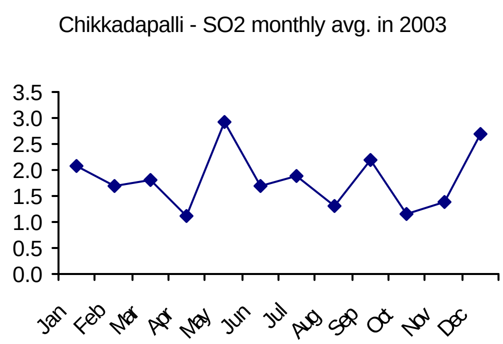

Jublee Hills - NO2 monthly avg. in 2003
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

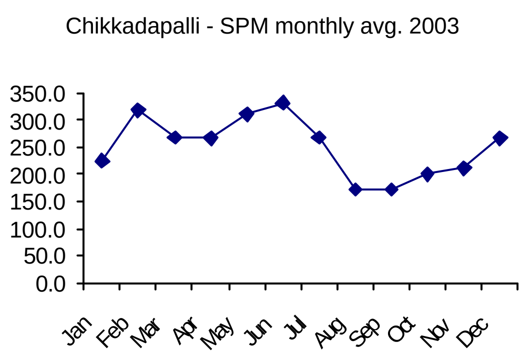

Jublee Hills - SO2 monthly avg. in 2003
1.5
1.3
1.0
0.8
0.5
0.3
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

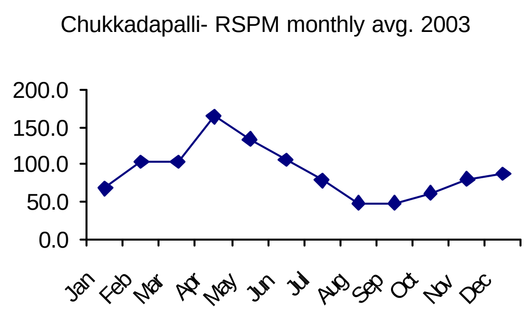

Jublee Hills - SPM monthly avg. in 2003
250.0
200.0
150.0
100.0
50.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Jublee Hills - RSPM monthly avg. in 2003
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

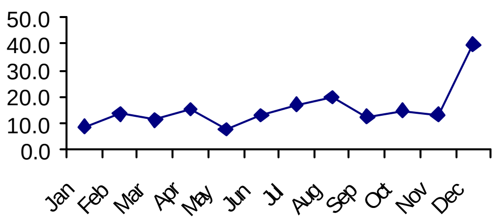

Chikkadapally - NO2 monthly Avg. in 2003
50.0
40.0
30.0
20.0
10.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Chikkadapalli - SO2 monthly avg. in 2003
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

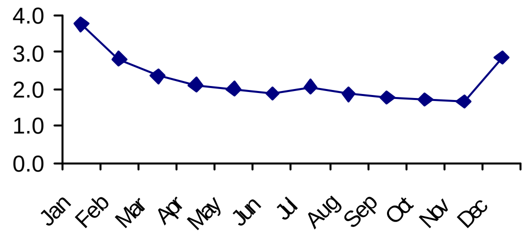

Chikkadapalli - SPM monthly avg. 2003
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec


Chukkadapalli- RSPM monthly avg. 2003
200.0
150.0
100.0
50.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

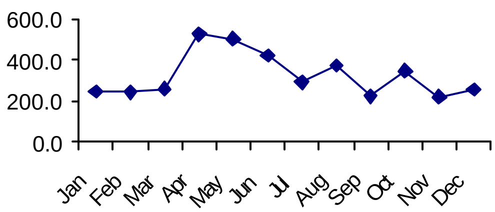
Jeedimetla - NO2 monthly avg. 2003



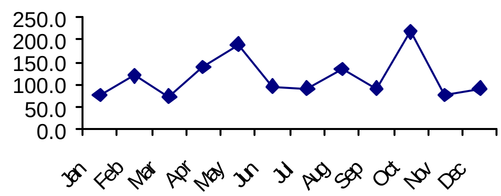
Jeedimetla - SO2 monthly avg. in 2003



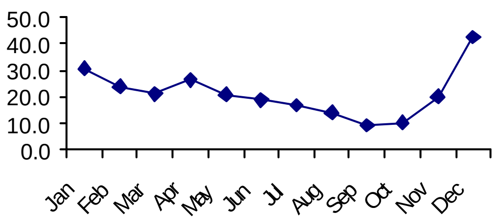
Jeedimetla - SPM monthly avg. 2003



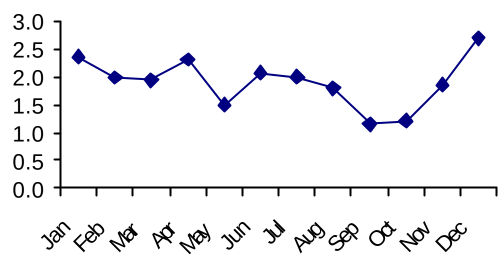
Jeedimetla - RSPM monthly avg. 2003



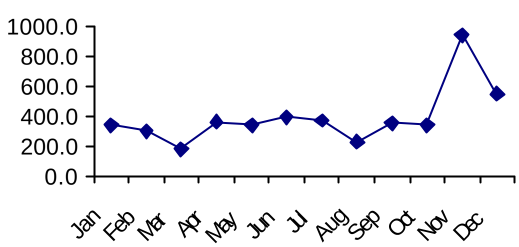
Langar House- NO2 monthly avg. 2003



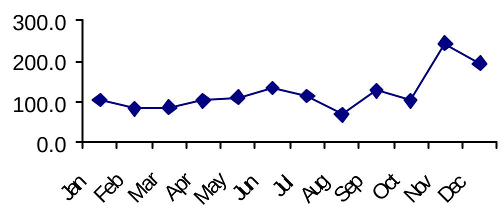
Langar House - SO2 monthly avg. 2003



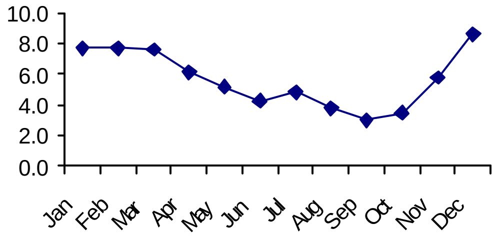
Langar House - SPM monthly avg. 2003



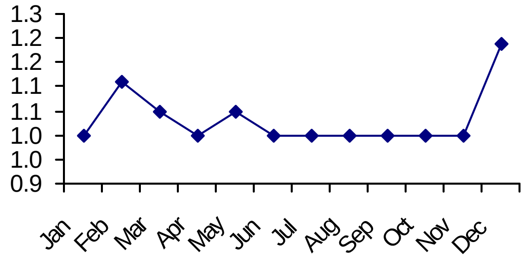
Langar House - RSPM monthly avg. 2003



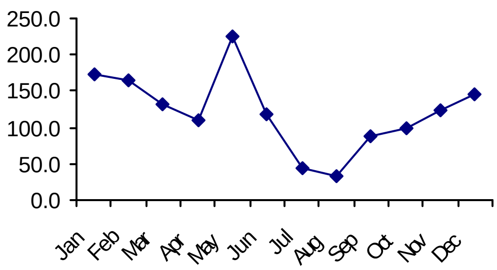
Madhapur - NOx monthly avg. 2003



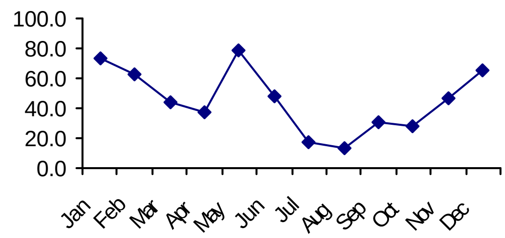
Madhapur - SO2 monthly avg. 2003



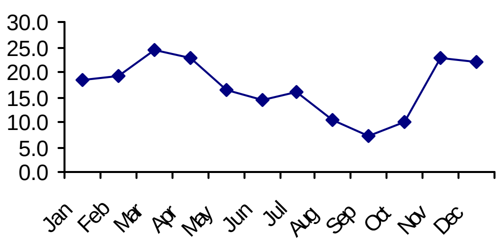
Madhapur - SPM monthly avg. 2003



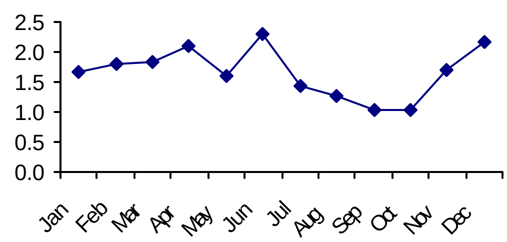
Madhapur - RSPM monthly avg. 2003



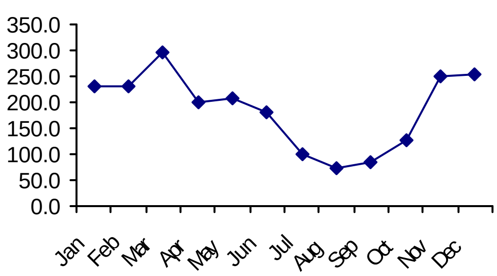
Kukatpally - NOx monthly avgg. 2003



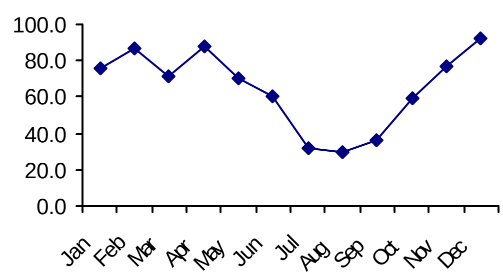
Kukatpally - SO2 monthly avg. 2003



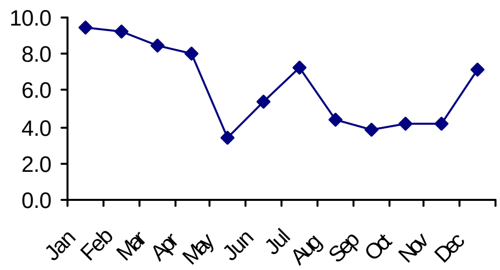
Kukatpally - SPM monthly avg. 2003



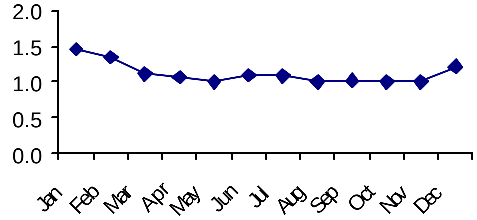
Kukatpally - RSPM monthly avg. 2003



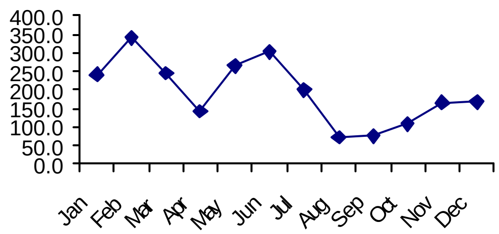
Sainkpuri - NOx monthly avg. 2003



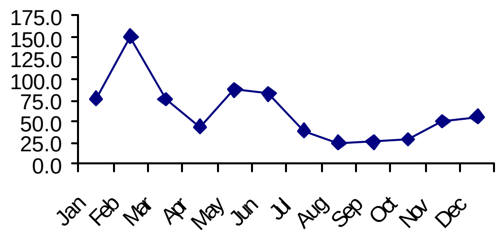
Sainikpuri- SO2 monthly avg. 2003



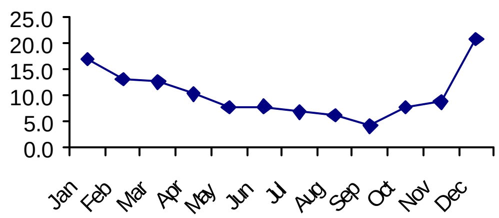
Sainikpuri - SPM monthly avg. 2003



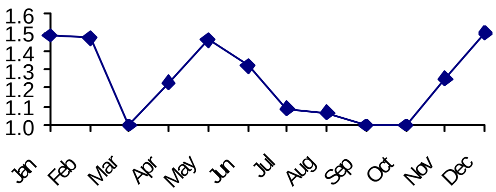
Sainikpuri - RSPM monthly avg. 2003



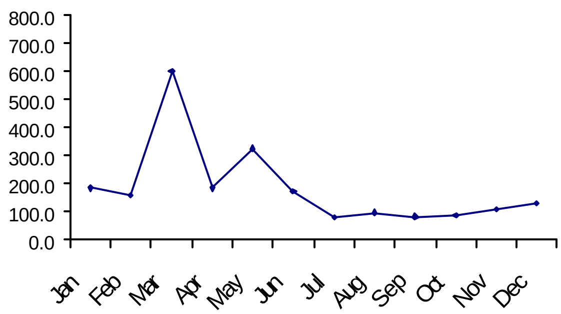
Begumpeta - NOx monthly avg. 2003



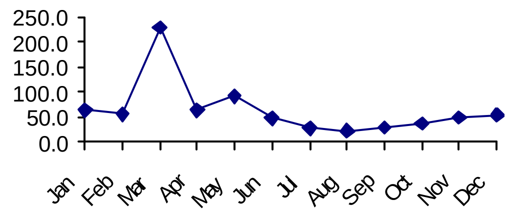
Begumpeta - SO2 monthly avg. 2003



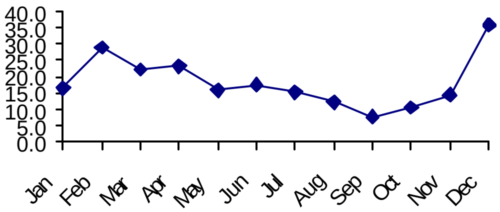
Begumpeta - SPM monthly avg. 2003



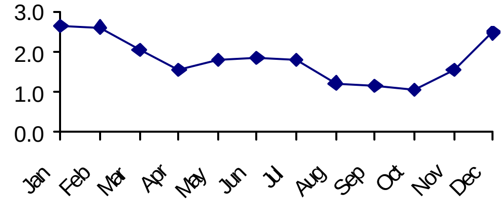
Begumpeta - RSPM monthly avg. 2003



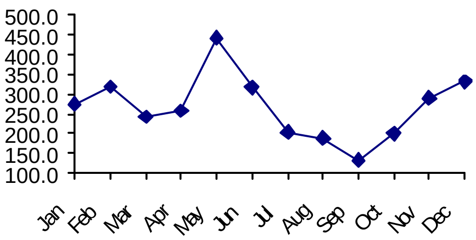
Nacharam - NO2 monthly avg. 2003



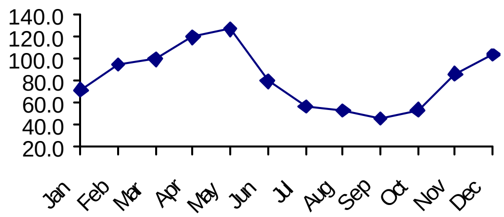
Nacharam - SO2 monthly avg. 2003



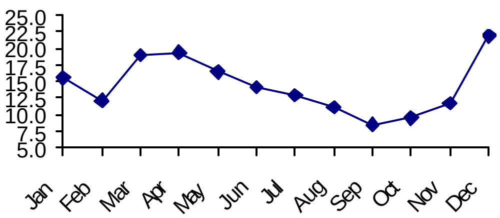
Nacharam - SPM monthly avg. 2003



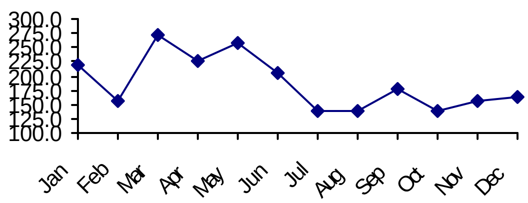
Nacharam - RSPM monthly avg. 2003



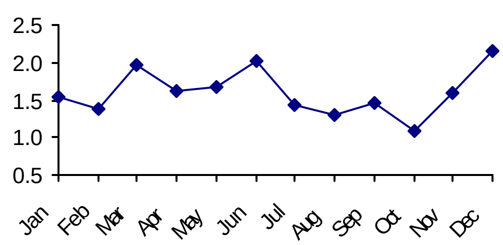
MG Bus Stn. - NO2 monthly avg. 2003



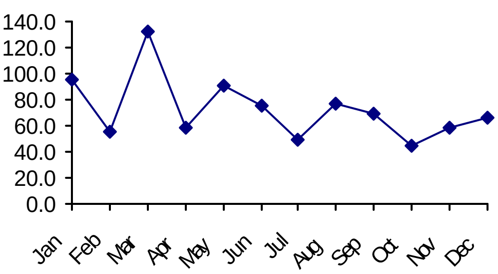
MG Bus - Stn. - SPM monthly avg. 2003



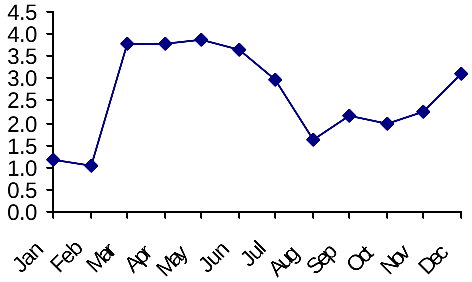
MG Bus Stn. - SO2 monthly avg. 2003



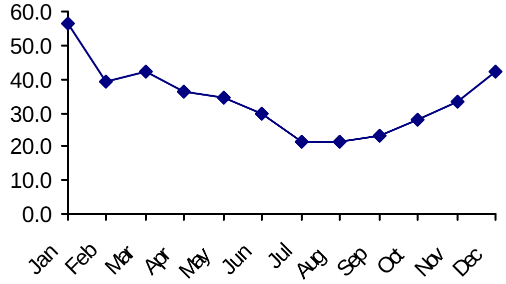
MG Bus- RSPM monthly avg. in 2003



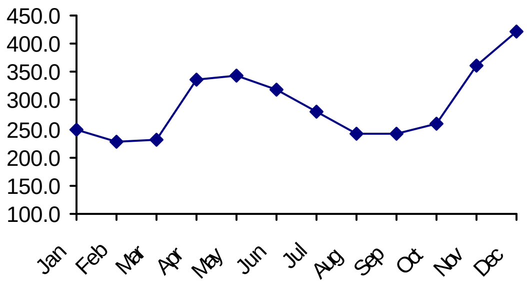
Paradise - SO2 monthly avg. in 2003



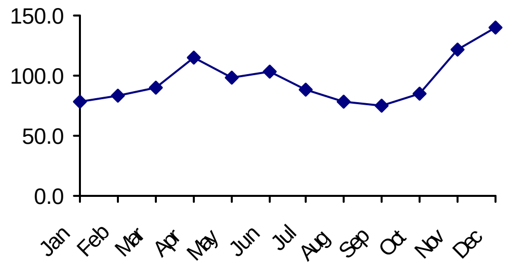
Paradise - NO2 monthly avg. in 2003



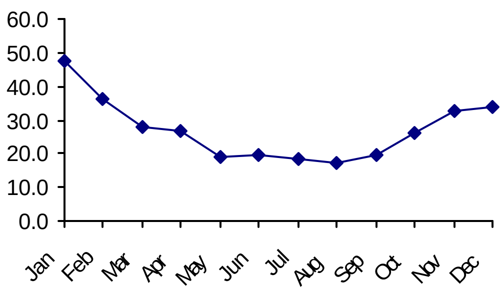
Paradise - SPM monthly avg. in 2003



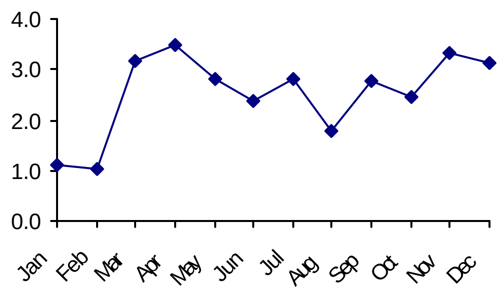
Paradise - RSPM monthly avg. in 2003



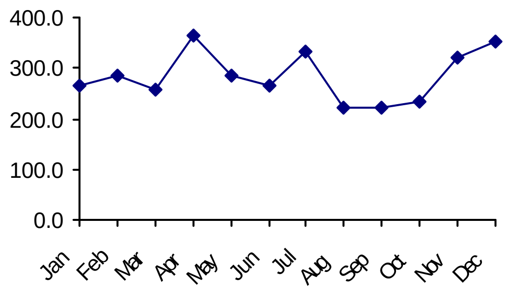
Punjagutta - NOx monthly avg. in 2003



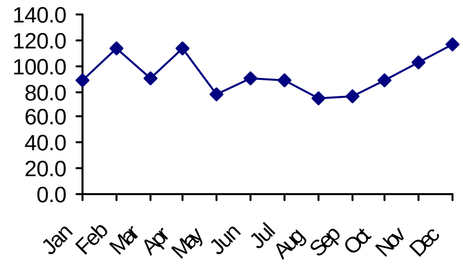
Puinjagutta - SO2 monthly avg. in 2003



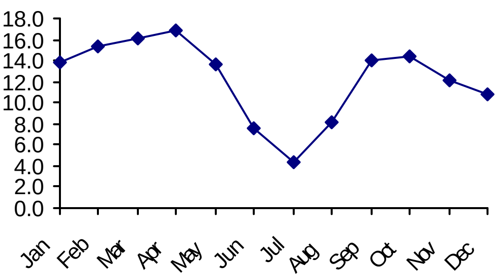
Punjagutta - SPM monthly avg. in 2003



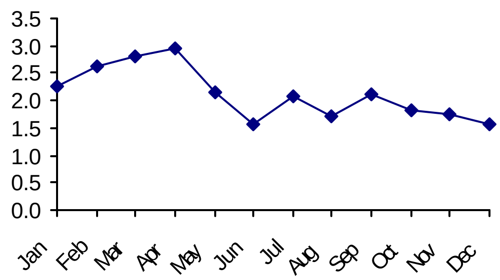
Punjagutta - RSPM monthly avg. in 2003



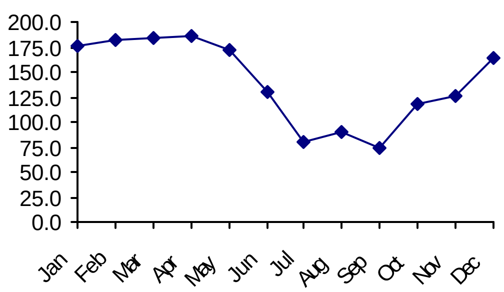
KBR Park - NO2 monthly avg. in 2003



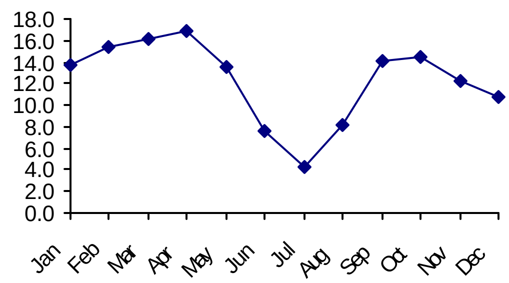
KBR Park - SO2 monthly avg. in 2003



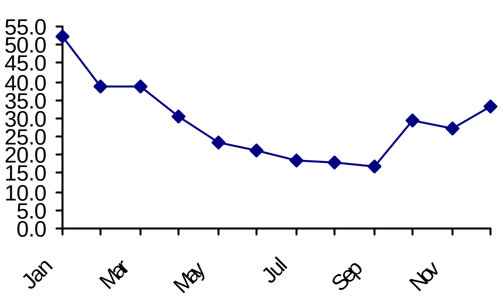
KBR Park - SPM monthly avg. in 2003



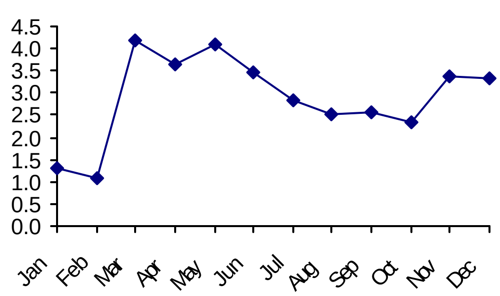
KBR Park - RSPM monthly avg. in 2003

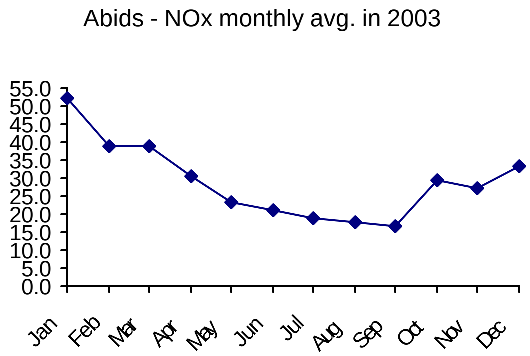


Abids - NOx monthly avg. in 2003



Abids - SO2 monthly avg. in 2003




Abids - NOx monthly avg. in 2003
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
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Jan
Feb
Mar
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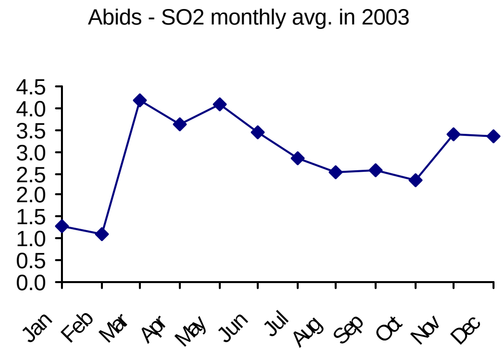
Aug
Sep
Oct
Nov
Dec


Abids - SO2 monthly avg. in 2003
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
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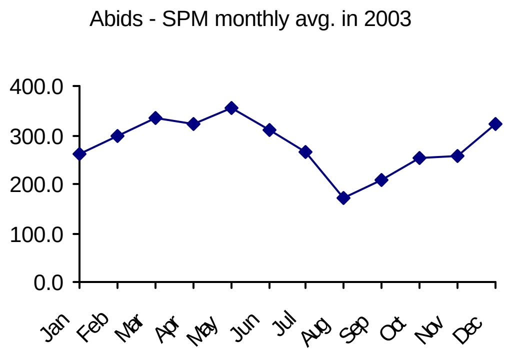
Sep
Oct
Nov
Dec


Abids - SPM monthly avg. in 2003
400.0
300.0
200.0
100.0
0.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

D. General Standards for Air and Water Pollutants

D1 General Standards For Discharge of Environment Pollutants

S.No	Parameters	Standards for discharges into			
		Inland surface	Public Sewers	Land for irrigation	Marine coastal areas
1	Suspended solids mg/L, Max.	100	600	200	a) For process waste water -100 b) For cooling water effulent10 percent above total suspended matter of influent
2	Particular size of suspended solids	Shall pass 850 micron sieve	-		a) Floatable solids max. 3 mm b) Settle able solids, max. 850 microns.
3	pH value	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
4	Oil and greasy mg/L, Max	10	20	10	20
5	Total residual chlorine mg/L, Max	1		_	1
6	Ammoniacal nitrogen (as N), mg/L, Max.	50	50	_	50
7	Total Kjeldahi nitrojen (as NH_3), mg/L, Max	100	_	_	100
8	Free ammonia (as NH_3) mg/L, Max.	5	_	_	5
9	Biochemical Oxygen demand (5 days at 20^0 C), mg/L, Max.	30	350	100	100
10	Chemical Oxygen demand, mg/L, Max.	250	_	_	250
11	Arsenic (as As), mg/L, Max.	0.2	0.2	0.2	0.2
12	Mercury (as Hg), mg/L, Max.	0.01	0.01	_	0.01
13	Lead (as pb), mg/l, Max.	0.1	1	_	2
14	Cadmium (as Cd), mg/L, Max.	2	1	_	2
15	Hexavalent chromium (asCr^{+6}), mg/L, Max.	0.1	2	_	1
16	Total chromium (as Cr), mg/L, Max.	2	2	_	2
17	Copper (as Cu), mg/L, Max.	3	3	_	3
18	Zinc (as Zn), mg/L, Max.	5	15	_	15
19	Selenium (as Se), mg/L, Max.	0.05	0.05	_	0.05
20	Nickel (as Ni), mg/l, Max.	3	3	_	5
21	Cyanide (as CN), mg/L, Max.	0.2	2	0.2	0.2
22	Florides (as F), mg/L, max.	2	15	_	15
23	Sulphide (as S), mg/L, Max.	2	_	_	5
24	Phenolic componds (as C_6h_5OH), mg/L, Max	1	5	_	5
25	Radioactive materials			_	
	(a) Alpha emitter Micro curie/ml	38632	38632	38633	38632
	(b) Beta emitter Micro curie/ml	38631	38631	38632	38631
26	Maganese (Mn) mg/L	2	2	_	2
27	Iron (as Fe) mg/L	3	3	_	3
28	Vaadium (as V) mg/L	0.2	0.2	_	0.2
29	Nitrate Nitrogen mg/L	10	_	_	20

D2 Air Quality Standards

		Concentration in Ambient Air		
Pollutant	Time Weighted Average	Industrial Area	Resident, Rural & Other Area	Sensitive
	Annual Average*	80mg/m^3	60 mg/m^3	15 mg/m^3
SO_2	24 hours**	120 mg/m^3	80 mg/m^3	30 mg/m^3
	Annual Average*	80 mg/m^3	60 mg/m^3	15 mg/m^3
No_x	25 hours**	120 mg/m^3	80 mg/m^3	30 mg/m^3
	Annual Average*	360 mg/m^3	140 mg/m^3	70 mg/m^3
SPM	25 hours**	500 mg/m^3	200 mg/m^3	100 mg/m^3
	Annual Average*	120 mg/m^3	60 mg/m^3	50 mg/m^3
RSPM	26 hours**	150 mg/m^3	100 mg/m^3	75 mg/m^3
	Annual Average*	1 mg/m^3	0.75 mg/m^3	0.5 mg/m^3
Lead (Pb)	26 hours**	1.5 mg/m^3	1 mg/m^3	0.75 mg/m^3
	8 hours**	5 mg/m^3	2 mg/m^3	1 mg/m^3
CO	1 hours**	10 mg/m^3	4 mg/m^3	2 mg/m^3