Ecological Impact Assessment
Series: EIAS/4/2009-10

CRITERIA FOR COMPREHENSIVE ENVIRONMENTAL ASSESSMENT of INDUSTRIAL CLUSTERS

Central Pollution Control Board
Ministry of Environment and Forests
Website: www.cpcb.nic.in • e-mail: cpcb@nic.in

DECEMBER 2009

CENTRAL POLLUTION CONTROL BOARD

APEX STATUTORY ORGANISATION FOR POLLUTION PREVENTION & CONTROL

INDIA

India has experienced multi-sectoral growth, at a geometrical progression rate, in manufacturing, transport, infrastructure, etc; in post-independence era. Therefore, the need for curbing an ever-increasing pollution due to change in the life style, is being seriously felt.

Central Pollution Control Board (CPCB) was established under statutory provisions of Water (Prevention and Control of Pollution) Act, 1974 with the main objective of maintaining the wholesomeness of water (surface and ground water) in India. The purview of the Board was widened further by provisions of other Acts and Rules there under, so as to cover compliance of other environmental components.

FUNCTIONS OF CENTRAL BOARD:
Besides main function of maintaining the wholesomeness of the water and improve air quality in India. The following are the other important supportive functions:

- Advise Central Government on prevention and control of environmental pollution;
- Coordinate activities of State Boards;
- Provide technical assistance and guidance to the State Boards;
- Organize training on pollution prevention & control;
- Organize Mass Awareness programs on pollution prevention & control;
- Perform as a State Board, as & when directed by Central Government;
- Collect, compile & publish technical & statistical data and also, prepare manuals, codes or guides related to prevention & control of environmental pollution;
- Lay down, modify and annul standards for quality of air & water;
- Execute nation-wide program on prevention & control of environmental pollution;
- Perform such other functions as may be prescribed by Government of India ;

The Board may establish or recognize laboratories to perform its functions.

CONTRIBUTION OF CPCB :

1. **Development of Standards:**
   - For Industrial effluent discharge: **43** Nos.
   - For Industrial emission release: **49** Nos.
2. **Preparation of Guidance Documents:**
   - CPCB publications : >**500** Nos.
   - Guidelines on Waste Management: **32** Nos.
   - Manuals on Laboratory Management: **18** Nos.
3. **Training programs in last 5 years: 200** Nos.
4. **National Ambient Monitoring Network:**
   - Air quality Monitoring Stations: **386** Nos. (including 40 continuous AAQM Stations)
   - Water Quality Monitoring Stations: **1429** Nos.
5. **Environmental surveillance of selected industries:** Approx. **300** Nos. per annum
6. **Compliance monitoring efforts led to Setting up of Common Environmental Infrastructure:**
   - Effluent Treatment Plants: **131** Nos. (Total 750 MLD Treatment capacity)
   - Waste Management Facilities for Hazardous Wastes: **34** Nos.
   - Bio-Medical Waste Management Facilities: **170** Nos.
7. **Patents obtained on R&D : 13** Nos.

WAYFORWARD FOR IMPROVED POLLUTION PREVENTION & CONTROL:

1. Escalated deployment of on-line monitoring systems enabling better environmental compliance by self-regulation at pollution sources.

2. Creation of a centralized data base on Process Technologies in use vis-à-vis Cleaner Technologies available globally.

3. Application of GIS based Environmental Impact Assessment of the Project under planning to improve the environmental decision-making process.

4. Promotion of common Environmental Infrastructural facilities for comprehensive waste management with various recycling options.

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Criteria for Comprehensive Environmental Assessment of Industrial Clusters

cpcb

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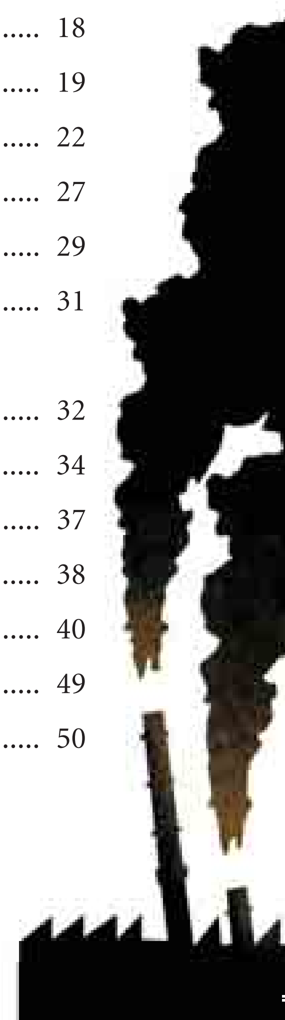

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Central Pollution Control Board
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Foreword

Pollution load in air, water, and soil is not just an environmental challenge, but synergistically a public health challenge as well. There is an urgent need to classify polluted industrial clusters based on scientific criteria and design action plans accordingly.

Comprehensive Environmental Pollution Index (CEPI) is a rational number to characterize the environmental quality at a given location following the algorithm of source, pathway and receptor. Increasing value of CEPI indicates severe adverse effects on environment and also is an indication of large percentage of population experiencing health hazards.

CEPI comprehensively captures various dimensions of pollution without loosing important information embedded into it. The aim of the study is to prioritize industrial clusters in the order of planning needs for interventions. CEPI therefore, forms the basis for comprehensive remedial action plan for the identified severely polluted/critically polluted industrial clusters.

The present CEPI is intended to act as an early warning tool, which is easy and quick to use. It can help in categorizing the industrial clusters/areas in terms of priority. These industrial clusters/areas shall be investigated to for defining the spatial boundaries as well as the extent of eco-geological damages. The outcome shall be subjected to structured consultation with the stakeholders for determining comparative effectiveness of alternative plans and policies. The effective implementation of the remedial action plan will help in abatement of pollution and to restore the environmental quality of these industrial clusters.

Evolving CEPI has been a comprehensive exercise of Central Pollution Control Board (CPCB) involving Ministry of Environment and Forests (MoEF), Indian Institute of Technology (IIT), Delhi, IIT Kanpur, IIT Kharagpur, IIT Roorkee, Delhi Technological University, TERI University, BITS Pilani, National Environmental Engineering Research Institute, Public Health Foundation of India and experts from various organizations, institutions, universities, industries and NGOs. Valuable contribution from the participants from these organizations is thankfully acknowledged.

Special thanks are due to Shri J S Kamyotra, Member Secretary, CPCB, and Shri A K Vidyarthi, Environmental Engineer, CPCB for their continuous efforts in evolving CEPI. Dedicated efforts in conceptualizing, testing and fine tuning the CEPI methodology by Dr Arvind K Nema, Associate Professor, IIT Delhi are thankfully acknowledged. Thanks are also due to Professor Mukesh Khare, Dr B J Alappat, and research staff at IIT Delhi for their sincere efforts in giving feedback and analysing the data and TERI for printing the script.

It is hoped that this report would be useful to all the concerned for improving environmental quality.

Prof. S P Gautam
Chairman, CPCB

'Parivesh Bhawan' C.B.D. cum Office Complex, East Arjun Nagar, Delhi - 110 032

Chapter 1
Introduction

Environmental pollution remains a serious issue in the developing world, affecting the lives of billions of people, reducing their life expectancy, and damaging children's growth and development. The World Heath Organization (WHO) estimates that 25% of all deaths in the developing world can be directly attributed to environmental factors. The problem of pollution, and its corresponding adverse ecological impacts have been aggravated due to increasing industrial and other developmental activities. India, among other developing nations of the world, is facing the challenge of industrial pollution at an alarming rate. This has made the constant surveillance of environmental characteristics a necessary task. There is an urgent need to identify critically polluted areas and identify their problematic dimensions. Accordingly, measures have to be taken to make our process of industrial development and economic growth more sustainable. The biggest hindrance in this task is the lack of tools to identify the problematic areas and the lack of an objective criterion to rank these areas in order of their needs for mitigation measures and, hence, the resources.

This has led to the realization of the need for an objective method so as to analyse the environmental conditions of the identified industrial clusters/areas. To accomplish this, it is required, at the first instance, to process the base level information and develop a robust methodology for identification and ranking of the selected industrial clusters/areas based on various dimensions of pollution.

Critically polluted industrial areas/clusters are not only environmental challenges but they are also public health challenges. Indeed, only a fraction of national/international efforts have been made, so far, for remediation of such critically polluted areas, despite their significant threat to environmental and public health. The comprehensive environmental pollution index

(CEPI) helps in quantifying the environmental health of the critically polluted areas by synthesizing available information on environmental status by using quantitative criteria.

For this purpose, various methods have been developed and evaluated in the past. However, there still exist enormous challenges in quantifying the environmental characteristics of critically polluted areas. A review on the environmental consequence estimation methods has been carried out to identify the gaps in the existing methods in assessing hazards due to environmental release of emissions in Chapter 2.

Chapter 3 underlines the development procedure of CEPI. This chapter describes an innovative method of developing CEPI for relative ranking of industrial areas/clusters based on properties of hazardous substances used, produced or stored; inventory of the substances; and environmental conditions of the locations under investigation. Different decision-making criteria have been incorporated in the development of CEPI.

Chapter 4 presents the summary and future roadmap.

Chapter 2

Quantification of Environmental Characteristics

NEED FOR QUANTIFICATION

Anthropogenic activities are one of the major sources of environmental pollution. In the recent past, the problem of pollution, and its adverse ecological impacts have been aggravated by an increase in the scale of residential, industrial, and other developmental activities including hydroelectric power plant projects, mining, and so on. This has led to a realization that there is a need to formulate an objective method to quantify the environmental conditions of such polluted areas. Besides, there has been a growing concern about environmental sustainability, which has attracted the concerted efforts of researchers from different disciplines including natural sciences, social sciences, engineering, and the humanities. The ever-increasing world population, coupled with the growing societal demands, have been triggering rapid pace of industrialization, resource extraction, and intensive production. Unfortunately, such swift industrialization and urbanization has caused negative environmental effects, damaging the ecosystem. Resource depletion, greenhouse effect, global warming, acidification, air pollution, water pollution, soil pollution, and their impact on human health are some of the major negative consequences. Broadly, these impacts may be categorized into two groups such as the following.

- Impacts on sensitive environment
- Impacts on humans

In both the cases, these impacts may be routed through surface and ground water, air, fire, and explosion or direct contact. Industrial releases to the environment can clearly have two types of impacts.

Methods like ecological risk assessment and environmental impact assessment are being used to determine the impact of developmental projects and other human activities in a region. Many researchers have used the techniques of geographic information systems (GIS) in the same but there is a critical need for adopting spatially explicit modelling approaches to handle the dynamics imposed by heterogeneous environments. One of the reasons that the demand for integrated environmental information has recently increased in many countries is because integrated information is essentially used in evaluating the performance of environmentally sustainable development.

Further, there have been various hazardous incidences in the past due to industrial pollution. These catastrophic incidences have made the public aware of current environmental issues. This awareness has brought worldwide concern for the environmental consequences of industrial pollution and, hence, the development of methods for its evaluation. As a result, several methods have been developed for the assessment of environmental consequences.

The aggregated measurement of environmental performance or sustainability, which is usually in the form of a comprehensive environmental pollution index (CEPI), has evolved as a focus in environmental systems analysis. CEPI offers decision-makers the condensed environmental information for performance monitoring, policy progress evaluation, benchmarking comparisons, and decision-making. CEPI reduces the number of indicators by aggregating them to make the information easily accessible; otherwise it is very difficult to evaluate the environmental performance on the grounds of so many environmental indicators. CEPIs are very valuable as a vehicle for providing environmental information in a clear and succinct manner. CEPIs are especially very useful for environmental decision-making by policy-makers, although environmental experts may have several means for analysing many indicators. However, decision-makers are much more likely to rely on integrated information such as the CEPIs (Kang 2002).

METHODS DEVELOPED FOR IDENTIFICATION AND QUALIFICATION

A large number of studies have, so far, been reported on the construction of the CEPI. They deal with cases that range from a specific environmental theme to the whole economic–energy–environmental system and from a single country/region to multiple countries/regions (Zhou, Ang, and Poh *et al.* 2005). In order to assess environmental consequences, various methods have been developed by researchers/academicians. Each method has its limitations, advantages, and applicability for different scenarios. Broadly, two separate sets of tools exist, first, the methods for identification and quantification of abnormal situations, that is, environmental hazards; and, second, the methods for quantification of planned releases or emissions (the environmental consequences include potential damage to both environment and humans).

Recent developments in this field involve the development of indices for inherent environmental safety and chemical process route selection based on Boolean mathematics. The use of fuzzy logic theory in the development of inherent safety index enhances the effectiveness of the results.

Various methods are available for forming environmental impact indices. These indices are of two major types, one, the indices based on the amount of waste produced and, second, indices based on the relative environmental effects of different key parameters such as pollutant emissions, land usage and energy consumption, as well as unquantifiable parameters like aesthetic value.

General structure of environmental indices

Figure 1 describes the general structure of environmental indices by showing the relation between environmental data, indicators, and indices.

The first step, in construction of an environmental index, consists of the collection of data pertaining to various environmental themes as mentioned above. The second step involves aggregation of the data related to environmental component indicators for example, water, air, soil, and so on. Each indicator is a mathematical function, which has been defined as variables characterizing the respective environmental components. These

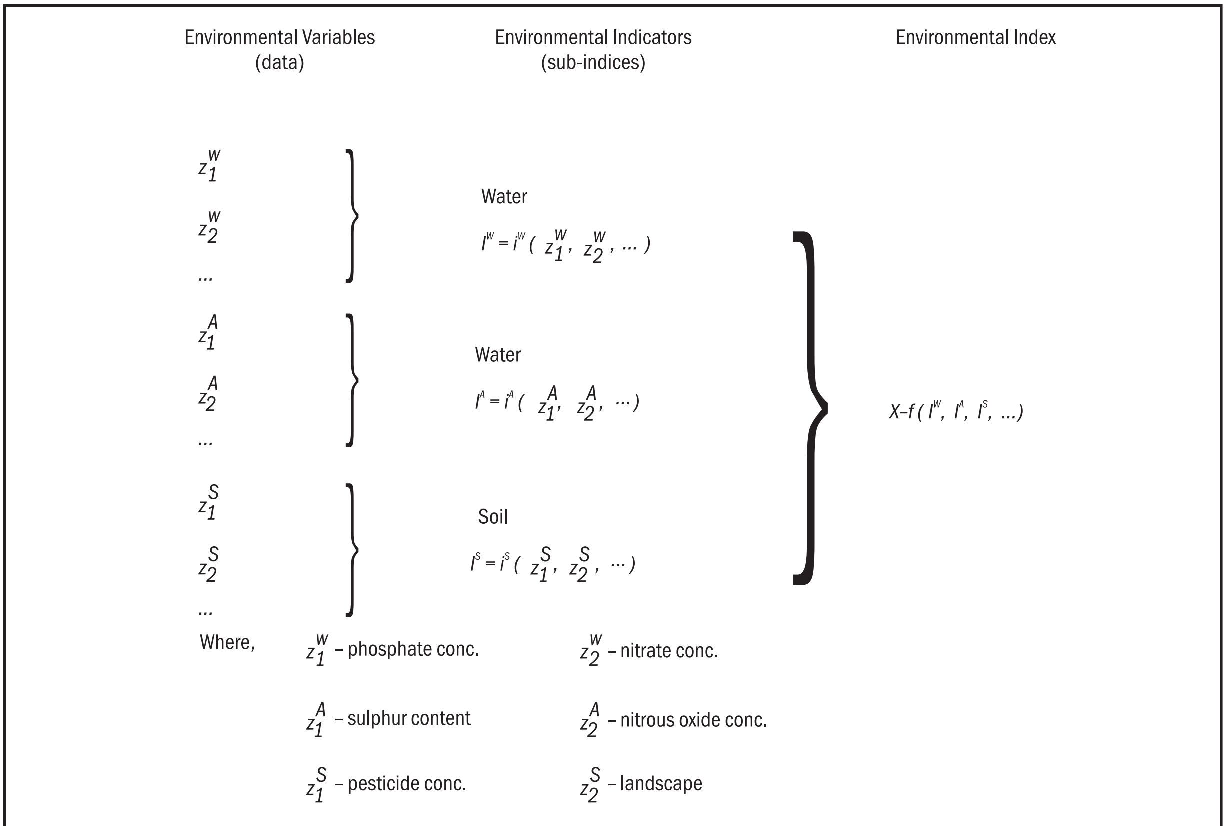


Figure 1 The relation between environmental data, indicators, and indices
Source Ahlheim (2005)

indicators serve as arguments of a mathematical function that describes the overall state of the environment by a single rational number, that is, the environmental index. Hence, indicators are often also referred to as sub-indices. At each stage of this aggregation process, information is lost on the one hand while simplicity and intelligibility of the environmental 'message' is gained on the other. Obviously, there is no single 'correct' way of aggregating, for example, air pollution data (nitrogen oxides, sulphur dioxide, carbon dioxide, and so on) to form an air quality indicator. There is always a certain degree of arbitrariness inherent in the choice of an aggregation function. It depends on the environmental component and the kind of variables to be described by the indicator.

An overview of the most important environmental indices, which are used in the practice of environmental monitoring, is given in the following section. There exist a variety of different indices and the examples that reflect the up to date developments.

Descriptive environmental indices

The construction of all descriptive indices follow a two-step procedure. In the first step, suitable indicators – representative for an environmental issue – are selected or created from the underlying data. Subsequently, the set of these indicators is aggregated to an overall index number using an appropriate aggregator function (Ahlheim 2005).

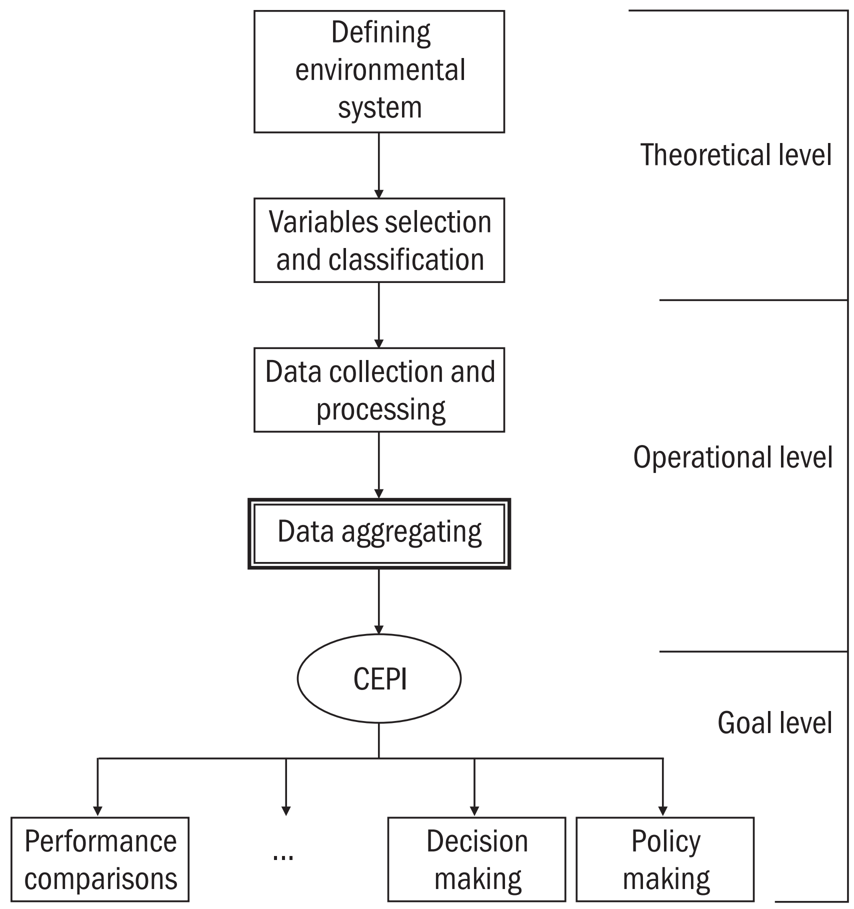


Figure 2 The construction process of CEPI

Normative indices

The normative indices combine the measurement of certain indicator values with a normative statement. One form of normative indices are the achievement indices that are designed to measure and visualize the extent to which a specific environmental goal (that is, the normative statement) has already been attained. Another form can be seen in the comparison of a state index with a normative statement of sustainability. The German Environmental Index (DUX), developed in 1999 for the specific purpose of conveying information about the effectiveness of national environmental policy to the general public, is an example of normative index. The aim of the set of indicators is to inform policy-makers and the public about spatial inequity with respect to environmental (living) conditions in order to identify those regions within a country that should be given high priority for environmental improvements.

The construction of these indicators is based on the relation of measured environmental data, for example, ambient pollutant concentration in a certain region to a threshold value (that is, the target) considered acceptable from a health-related point of view. As such, these set of indicators are purely based on expert knowledge. The so-called ecological footprint (EF), as an example of a sustainability index, represents a normative index in the sense that it allows the direct comparison to a normative measure of sustainability.

Some popularly used tools for environmental quantification are described as below.

- *Hazardous ranking system* This has been adopted by the Environment Protection Agency, United States (USEPA). The hazardous ranking system (HRS) is a numerically based screening system to assess the relative potential of sites to pose a threat to human health or the environment. The US EPA scores four pathways under the HRS, which includes groundwater, surface water, soil exposure, and air migration.
- *Air quality index* The AQI is calculated by using pollutant concentration data, a given table, using the following equation (linear interpolation).

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}} (C_p - BP_{Lo}) + I_{Lo}$$

Where I_p = the index for pollutant p; C_p = the rounded concentration of pollutant p; BP_{Hi} = the breakpoint that is greater than or equal to C_p; BP_{Lo} = the breakpoint that is less than or equal to C_p; I_{Hi} = the AQI value corresponding to BP_{Hi}; I_{Lo} = the AQI value corresponding to BP_{Lo}.

MAIN CHARACTERISTICS OF AN ENVIRONMENTAL INDEX

Such indices are typically informational tools used for communication between environmental experts, politicians, and the public at large. To this end, environmental indices are presumed to make complex and detailed information on the state of the environment simpler and more lucid.

They may serve as a means of resource allocation, of judging and comparing the quality of different locations, of measuring the success of environmental policy or of informing the public on the development of environmental quality in a country or in certain geographic regions. This multipurpose character of environmental indices imply the well-known dilemma inherent in this concept, that is, the environmental index should be easy to understand and interpret for laymen and the information it conveys should not be trivial or too superficial.

Their construction implies a reduction of complex, multidimensional environmental specifics to a single number, which goes along with a considerable loss of information as compared to the original data set underlying the respective indices. The reason why one is willing to accept this loss of information is the hope that more people will be interested in such a condensed informational tool than in the complex data set on which it is based. The intention to find the middle ground, between these two claims, has led to constructions that are neither noticed by the people nor are very instructive from a scientific point of view (Ahlheim 2005).

CHALLENGES FACED

Lack of basic environmental monitoring and hence the data, deficient information on environmental and public health effects of pollutants, arbitrary selection of weights assigned to environmental themes, and a lack of rationale in the use of the index are the major problems to be dealt with in the process of creating an environmental index, and its further application. There also lies a major problem of loss of information. It is necessary to strike a balance between the simplicity of usage of the index, and its scientific correctness. The comparison of the index values to classify critically polluted areas is also a debatable issue. One of the main experiences in research (EQI), thus far, has been that the reductionist approach has failed to analyse adequately the complex, multidisciplinary, and large-scale global phenomena. The EQIs currently in use are not organized within any integrated framework. This implies that they do not yield information about linkages between causes and effects nor cross-linkages between various causes and various effects.

A major problem in constructing the CEPI is the determination of an appropriate aggregating method to combine multidimensional environmental variables into an overall index. Despite the existence of large number of CEPIs, there is a lack of objective criteria for choosing an appropriate aggregating method (Kang 2002). A meaningful environmental index has been defined as an index for which the underlying ranking order is independent of the choice of the measurement units. It has been described that the CEPI aggregated by the weighted geometric mean method is meaningful when the environmental variables are strictly positive and when the ratio-scale is incomparable. It has been observed that CEPIs by the weighted sum method are generally not meaningful.

If the environmental variables are normalized and become dimensionless before aggregating, the CEPIs given by the weighted geometric mean and weighted sum methods are both meaningful and the two methods become incomparable, though there will always be subjectivity in selecting the contributing factors in the index.

The problem of choosing the response function is also to be handled. Even if there are a large number of various environmental factors, usually we can identify many factors that have an impact on the index. The impact of the other factors can be regarded as 'ecological noise.'

Loss of information, while aggregating sub-indices, is also a major problem that poses a challenge to the authenticity of a comprehensive environmental index. If an aggregating method would always result in few loss of information in contrast to other aggregating methods, it might be regarded as a better aggregating method. If the aggregating method used is a perfect method, there would be no loss of information.

The dilemma between comprehensibility and scientific profoundness is also not easy to resolve. The computation of a pollution index is meant to be particularly simplified by the use of selected environmental quantities that are representative, that is, indicative, of some theme related to pollution. However, no solution can be proposed to determine the relative importance of pollution themes in an objective way.

Chapter 3

Comprehensive Environmental Pollution Index

The goal of this project is to prioritize critically polluted industrial clusters/areas based on scientific criteria. For this purpose, base level information is needed so that a robust methodology can be developed. In such a measure, various dimensions of pollution are to be captured.

The index may then be used for quantification of the environment, health, determining the effectiveness, and comparing alternative plans and policies in order to help environmental decision-makers.

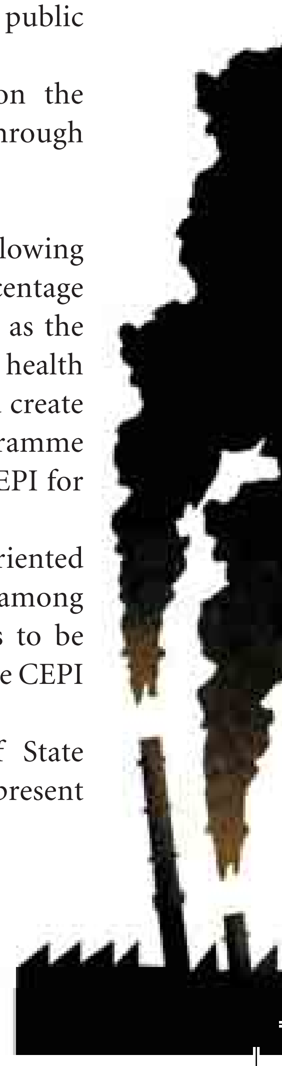
The main objectives of the CEPI project are as follows.

- To identify critically polluted industrial clusters/areas from the point of view of pollution and taking concerted action and for being centrally monitored at the national level to improve the current status of environmental components, for example, air and water quality data, public complaints, ecological damage, and visual environmental conditions.
- To facilitate the definition of critically polluted industrial clusters/areas based on the environmental parameter index and prioritization of an economically feasible solution through the formulation of an adequate action plan for environmental sustainability.

CEPI is a rational number to characterize the quality of the environment at a given location following the algorithm of source, pathway, and receptor. As CEPI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. As far as the role of the environmental pollution index in identifying and assessing the environmental health of critically polluted area is concerned, it is required to identify environmental aspects and create an asset of core pollutants adopted for each industrial cluster, develop monitoring programme for set of pollutants selected, develop the database for CEPI, and process it and develop CEPI for industrial clusters.

The index being evaluated, developed, and used here is a holistic, integrated, systems-oriented approach, which concentrates on the cause–effect interactions and feedback mechanisms among different subsystems rather than focusing on each subsystem in isolation. This appears to be promising as a conceptual tool for understanding and comparing environmental indices. The CEPI developmental process involved a brain storming workshop conducted at IIT Delhi.

The workshop was inaugurated by Shri Jairam Ramesh, Honorable Minister of State (Independent Charge), Environment and Forests, Government of India. Other dignitaries present



included Prof. S P Gautam, Chairman, Central Pollution Control Board (CPCB); Shri J S Kamyotra, Member Secretary, CPCB; Prof. S M Ishtiaque, Deputy Director (Administration), IIT Delhi; and Dr K Srinath Reddy, President, Public Health Foundation of India (PHFI).

Prof Mukesh Khare and Dr Arvind K Nema, IIT Delhi, presented the methodology and framework of the proposed CEPI for industrial clusters. Eight groups of experts were formed for evaluating various industrial clusters/area to gather a feedback on developed methodology and framework to quantify CEPI. Each group contained four to five members including experts from academia, research, industry, NGOs, and regulatory agencies.

Four case studies of listed full out CPAs were given to each group, out of which case studies of Angul Thalchar and Ankleshwar area were common to all eight groups. This was done to assess and evaluate CEPI, and then to compare the score in order to evaluate the difference in CEPI score by different groups. The rest of the case studies were different for different groups. The feedback from the workshop was used to finalise the proposed CEPI.

Proposed comprehensive environmental pollution index for industrial clusters

Scope of the proposed CEPI

- The proposed CEPI is aimed at evaluating the areas primarily subjected to industrial pollution.
- CEPI is aimed at assessing the effect of pollution at the local level around industrial clusters. The global environmental issues are not covered by the proposed CEPI.
- CEPI does not reflect the potential accidental release of pollutants in the area or in a nearby area.

Framework

A comprehensive CEPI to assess the industrial clusters/areas is a three-step process (as described below).

STEP I The status of the area is assessed based on ground information. The framework proposed is as follows.

Source → Pathways → Receptor

STEP II Various environmental indicators are assessed and the status of environmental resources such as land, vegetation, air, and water is investigated. Spatial and temporal data/information shall be used for this purpose.

STEP III Structured consultation with the following.

- Local stakeholders
- Experts
- Policy-makers

The present method of calculating CEPI is aimed to carry out preliminary screening of the polluted industrial clusters/areas following Step I. The outcome may be used for formulating immediate preventive and control actions.

The present CEPI is intended to act as an early warning tool, which is easy and quick to use. It can help in categorizing the industrial clusters/areas in terms of priority.

It is to be noted that the data/information available with CPCB and concerned State Pollution Control Boards (SPCBs)/PCCs for the industrial areas/clusters have been used in Step I.

Additional information shall be collected and used corresponding to Steps II and III as the future course of action. These industrial clusters/areas shall be subjected to detailed environmental investigations (Step II and III) for defining the spatial boundaries as well as the extent of eco-geological damages. The outcome of Step II and III shall be used for preparing a comprehensive remedial action plan.

Scoring methodology

The scoring system involves an algorithm that takes into account the basic selection criteria. This approach is based on the basic hazard assessment logic that can be summarized as below.

Hazard = pollutant source, pathways, and receptor

Each of these essential links in the causal chain is represented by criteria that are included in the scoring methodology.

CEPI is calculated separately for air, water, and land in selected industrial cluster/area.

The basic framework of the proposed CEPI – based on three factors namely pollutant, pathway, and receptor – has been described below.

POLLUTANT (up to three most critical pollutants to be taken)

- Factor #A1 – Presence of toxin
  - Group A – Toxins that are not assessed as acute or systemic = 1
  - Group B – Organics that are probable carcinogens (USEPA Class 2 and 3) or substances with some systemic toxicity, for example, VOCs, PAHs, PCBs, PM_{10} and $PM_{2.5}$ = 2 (refer Appendix 1 for list of Group B pollutants)
  - Group C – Known carcinogens or chemicals with significant systemic or organ system toxicity, for example, vinyl chloride, benzene, lead, radionuclide, hexachromium, cadmium, and organophosphate = 4 (refer Appendix 2 for list of Group C pollutants)

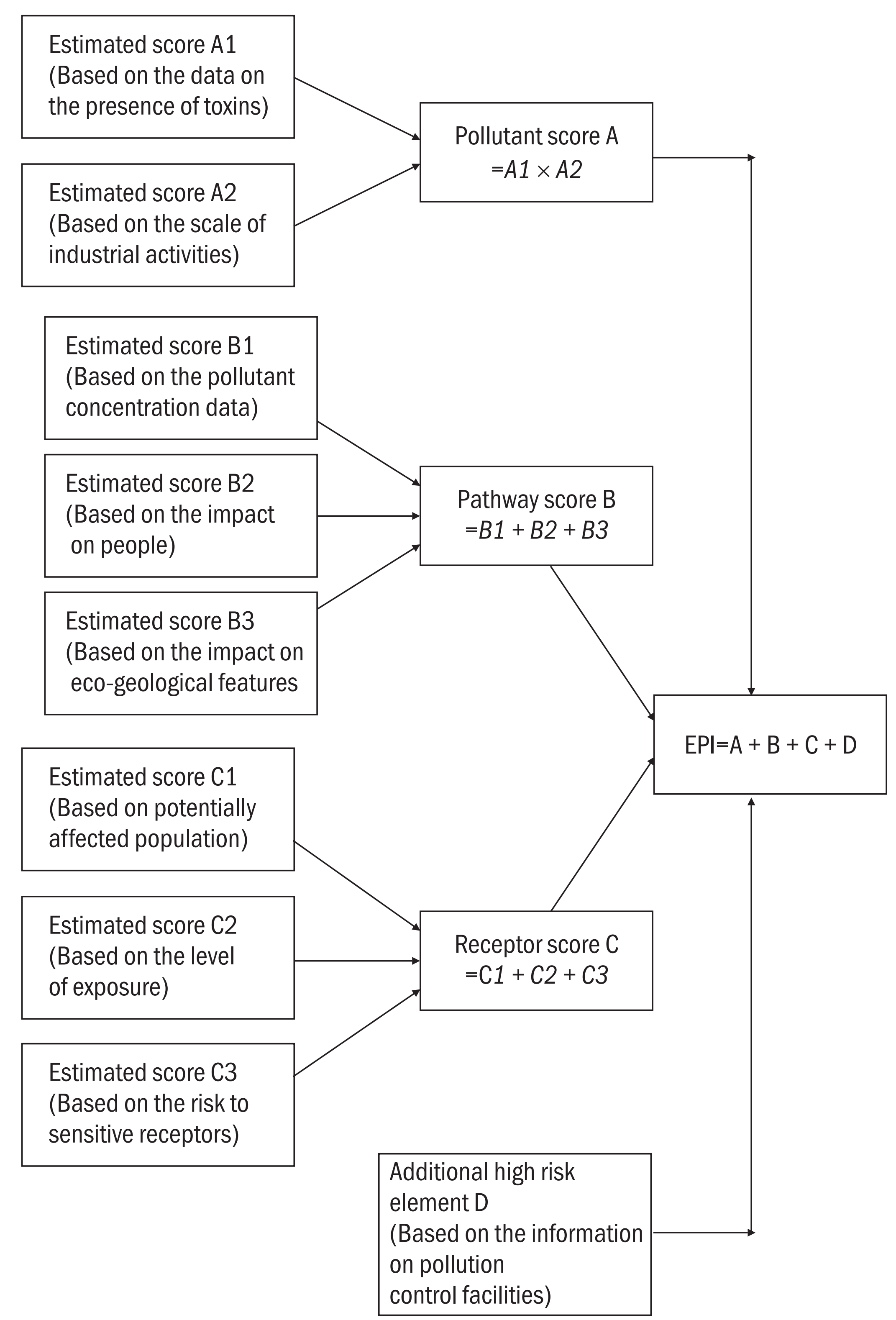


Figure 3 CEPI calculation methodology

Table 1 Penalty values for combination of most critical pollutants Factor A1

S No.	Pollutant 1	Pollutant 2	Pollutant 3	Penalty
1.	C	C	C	2.0
2.	C	C	B/A	1.75
3.	C	B	B/A	1.5
4.	B	B	B/A	1.0

- Factor #A2 – Scale of industrial activities
  - Large = 5 (if there are
    $\geq$ 10 R17* per 10 km^2 area or fraction OR
    $\geq$ 2 R17 + 10 R54** per 10 km^2 area or fraction OR
    $\geq$ 100 R54 per 10 km^2 area or fraction

**R17 are 17 category of highly polluting industries other than red category industries categorized by CPCB (list of industries in Appendix 3)*

*** R54 are red category industries categorized by Central Pollution Control Board (list of industries in Appendix IV)*

  - Moderate = 2.5 (if there are
    2 to 10 R17 per 10 km^2 area or fraction OR
    10-100 R54 10 km^2 area or fraction
  - Limited = 1 (else there is any industry within 10 km^2 area or fraction)

These two factors are taken as multiplicative and so the overall score for this element is as follows.

  - SCORE A = A1 × A2 (max score = 6 × 5 = 30)

PATHWAY

- Factor #B1 – Ambient Pollutant Concentration (Standards of Pollutant Concentrations are given in Appendix 5).
  - Critical = 6 (when exceedence factor* is more than 1.5)
  - High = 3 (when exceedence factor is between 1 and 1.5)
  - Moderate = 2 (when exceedence factor is between 0.5 and 1.0)
  - Low = 1 (when exceedence factor is < 0.5)

** The calculation procedure of exceedence factor is given in Appendix 6.*

Table 2 Penalty values for combination of most critical pollutants Factor B1

S No.	Pollutant 1	Pollutant 2	Pollutant 3	Penalty
1.	Critical	Critical	Critical/high/moderate	2.0
2.	Critical	High	High/moderate	1.75
3.	High	High	High	1.5
4.	High	High	Moderate	1.0

- Factor #B2 – Evidence* of adverse impact on people
  - No = 0 (when no reliable evidence is available)
  - Yes (when evidence of symptoms of exposure) = 3
  - Yes (when evidence of fatality or disease(s) leading to fatality (such as cancer) due to exposure) = 6

- Factor #B3 – Reliable evidence of adverse impact on eco-geological features
  - No = 0 (when no reliable evidence is available)
  - Yes (when evidence of symptoms of exposure) = 3
  - Yes (when evidence of loss of flora/fauna/significant damage to eco-geological features, (irreparable loss/damage)) = 6

(Reliable evidence is in form of media reports, hospital records, public interest litigations (PIL) and NGOs reporting, academic research reports, published literature).*

Overall score for this element is as follows.

SCORE B = B1 + B2 +B3 = (8 + 6 + 6) = 20

RECEPTOR

- Factor #C1 – Number of people potentially affected within 2 km radius from the industrial pollution source.
  - <1000 = 1
  - 1000 to 10 000 = 1.5
  - 10 000 to 100 000 = 3
  - > 100 000 = 5

- Factor #C2 – Level of exposure
  - A surrogate number, which will represent the level of exposure (SNLF) is calculated using percentage violation of ambient pollutant concentration, which is calculated as follows.

SNLF = (Number of samples exceeded/total number of samples) × (Exceedence factor)

– Low = 1 (SNLF = 0)
– Moderate = 1.5 (SNLF < 0.25)
– High = 2 (SNLF 0.25 - 0.5)
– Critical = 3 (SNLF > 0.5)

Table 3 Penalty values for combination of most critical pollutants Factor C1

S No.	Pollutant 1	Pollutant 2	Pollutant 3	Penalty
1.	Critical	Critical	Critical/high/moderate	2.0
2.	Critical	High	High/moderate	1.75
3.	High	High	High	1.5
4.	High	High	Moderate	1.0

Factors C1 and C2 are taken as multiplicative.

- Factor #C3 – Additional risk to sensitive receptors
  - No = 0
  - Yes (if > 500 sensitive people/ a sensitive historical/ archaeological/ religious/ national parks/ sanctuary/ecological habitat are within 2 km distance from source, additional risk) = 5

SCORE C = (C1 × C2) + C3 (max score = (5 × 5) + 5 = 30)

ADDITIONAL HIGH-RISK ELEMENT

- Factor #D – Additional high-risk element (inadequacy of pollution control measures for large-scale, medium- and small-scale industries and also due to the unorganized sector). It is cumulative of effluent treatment plants (ETPs), common effluent treatment plants (CETPs), air pollution control devises (APCDs), and unorganized waste disposal. Maximum score = 20
  - If all the industries in the area have adequately designed/operated and maintained pollution control facilities and also common facilities, such as CETP/EETP/CHWDF, this means that they have adequate capacity and are having state-of-the-art technology = 0.
  - If all the large industries in the area have adequately designed/operated and maintained pollution control facilities but small and medium industries are defaulting. Common facilities, such as CETP/FETP/CHWDF, are having adequate in capacity or operation/ maintenance = 5.
  - If all the industries in the area have adequately designed/operated and maintained pollution control facilities but the common facilities, such as CETP/FETP/CHWDF, are having inadequate in capacity or operation/maintenance = 10.
  - If all the large industries in the area have adequately designed/operated and maintained pollution control facilities but small- and medium-industries are defaulting. Common facilities, such as CETP/FETP/CHWDF, are having inadequate in capacity or operation/ maintenance = 15.
  - Inadequate facilities of individual as well as common facilities, full penalty = 20.

Table 4 Score for additional high-risk element: Factor D

S No.	Large- scale industries	Small/medium -scale industries	Common facilities for pollution control	Score
1.	Adequate	Adequate	Adequate	0
2.	Adequate	Inadequate	Adequate	5
3.	Adequate	Adequate	Inadequate	10
4.	Adequate	Inadequate	Inadequate	15
5.	Inadequate	Inadequate	Inadequate	20

Inadequate facilities $\geq$ 10% units deficient in terms of design/operation and maintenance of pollution control in case of small- and medium-scale industries OR $\geq$ 2% units deficiency in terms of design/operation and maintenance of pollution control in case of large-scale industries or common facilities.

The status report (last two years) shall be used deciding the score for adequacy.

Calculation of the Sub-Index

After calculating A, B, C and D; calculate the sub index score as:

Sub-Index SCORE = (A + B + C + D) = (30 + 20 +30 +20) = 100

Sub index scores are to be calculated for each of the individual environmental components that is, Air Environment, Surface Water Environment, and Soil & Ground Water Environment separately.

Calculation of the Aggregated CEPI

The aggregated CEPI Score can be calculated as.

$$\mathbf{CEPI = i_m + \{(100 - i_m) \times (i_2/100) \times (i_3/100)\}}$$

Where, i_m – maximum sub index; and i_2, and i_3 are sub indices for other media

GUIDELINES FOR APPLICATION OF CEPI

The CEPI, which is formulated, is user-friendly in terms of its application to industrial clusters/ areas. It needs sufficient pollution monitoring data and evidences of impact and other necessary information about the areas. To further simplify and expedite the use of CEPI by anyone, with little or no knowledge of environmental pollution, the guidelines for using the same have also been formulated. However, this becomes difficult when the required data is not available, then subjectivity comes into application.

To calculate various factors contributing to sub-indices and their values, the following procedure should be followed.

Determining critical pollutants

Three most critical pollutants are to be considered for calculation and these are selected in the beginning of the process. The pollutants are divided into three groups, that is, A, B, and C. This information can be obtained from the Annexure 5. Pollutants belonging to Group C are more critical than those belonging to Group B, which is more critical than those in Group A. In cases with more than three pollutants in the same category exist, the ones with higher concentrations in the surroundings would be considered critical.

Calculating pollutant factor A

Factor # A1 Based on the groups of the three critical pollutants, following values are used for calculating A1.

- Group A – A1 = 1
- Group B – A1 = 2
- Group C – A1 = 4

The final value of A1 is calculated by the addition of penalty for the given combination of critical pollutants to the maximum value of A1 for them.

For example, critical pollutants: Benzene – 35.8 μg/m^3 (C), RSPM – 172 μg/m^3 (B), SO_2 – 130 μg/m^3 (A); so, maximum value of A1 is for benzene = 4 and from the table: this lies in 'any other combination' and, hence, the penalty = 0.0. Hence, A1 = 4 + 0 = 4.0

Factor # A2 – The number of R17 and R54 (as given in list of industries in Annexure 4) industries per 10 km^2 area or fraction is determined and A2 is calculated based on the following criteria.

- Large – A2 = 5 : if there are
  - $\geq$ 10 R17 OR
  - $\geq$ 2 R17 + 10 R54 OR
  - $\geq$ 100 R54

- Moderate – A2 = 2.5 : if there are
  - 2–10 R17 OR
  - 10–100 R54
- Limited – A2 = 1 : in all other cases

For example, an area has five thermal power plants, 10 mining industries, and 40 small-scale industries of various kinds. Now, since both thermal power plants and mining industries lie in the R17 category, total R17 industries = 15 and, hence, A2 = 5.

Then calculate the pollutant factor A using: $A = A1 \times A2$

Calculating pathway factor B

Factor # B1 This is calculated based on the exceedence factor (F). (Calculation of exceedence factor is given in Annexure 5).

- Critical – B1 = 6 ($F \geq 1.5$)
- High – B1 = 3 (F = 1.0 to 1.5)
- Moderate – B1 = 2 (F = 0.5–1.0)
- Low – B1 = 1 ($F < 0.5$)

The final value of B1 is calculated by the addition of penalty for the given combination of critical pollutants to the maximum value of B1 for them.

For example, critical pollutants: Benzene – 35.8 $\mu g/m^3$ (15), RSPM – 172 $\mu g/m^3$ (150), SO_2 – 130 $\mu g/m^3$ (120). So, F (Benzene) = 2.4 and, hence, it is critical (6).

F (RSPM) = 1.14 and, hence, it is high (3)

F (SO_2) = 1.08 and, hence, it is high (3)

So, this is corresponding to serial number 2 in the table for Factor # B1 and, hence, penalty = 1.75 so, B1 = 6 + 1.75 = 7.75

Factor # B2 Reliable evidence of symptoms of adverse impact on people or fatality due to exposure is collected. Reliable evidence is in the form of media reports, hospital records, public interest litigation (PIL), and non-governmental organizations (NGOs) reporting, academic research reports, published literature.

- No – B2 = 0
- Evidence of symptoms – B2 = 3
- Evidence of fatality – B2 = 6

Factor # B3 Similar to the previous factor, reliable evidence of adverse impact on ecological features is collected.

- No – B3 = 0
- Evidence of symptoms – B3 = 3
- Evidence of significance damage – B3 = 6

Now calculate the pathway factor B using $B = B1 + B2 + B3$

Calculating receptor factor C

Factor # C1 For air pollution, number of people affected within 2 km radius from the industrial pollution source including industrial workers, and their families is estimated. For all others, total population of the area can be considered.

- $<1000 = 1$
- 1000 to 10 000 = 1.5
- 10 000 to 100 000 = 3
- $>$ 100 000 = 5

Factor # C2 To calculate C2, SNLF is first calculated where, SNLF = (number of samples exceeded the standards/total number of samples) × (average exceedence factor).

- Low – C2 = 1 (SNLF = 0)
- Moderate – C2 = 1.5 (SNLF $<$ 0.5)
- High – C2 = 2 (SNLF 0.5–1)
- Critical – C2 = 3 (SNLF $\geq$ 1)

The final value of C2 is calculated by the addition of penalty for the given combination of critical pollutants to the maximum value of C2 for them.

For example, critical pollutants: Benzene – exceeded for 8 out of 12 days of monitoring, RSPM –11 out of 12, SO_2 – 4 out of 12

Using the exceedence factor (F) calculated in B1;

SNLF (Benzene) = 2.4*8/12 = 1.6 => Critical (3)

SNLF (RSPM) = 1.14*11/12 = 1.045 => Critical (3)

SNLF (SO_2) = 1.08*4/12 = 0.36 => Moderate (1.5)

So, this corresponds to the S No. in the table for Factor # C2 and, hence, the penalty = 2.0. So, C2 = 3 + 2 = 5.0

Factor # C3 Additional risk to sensitive receptors, that is, sensitive people/a sensitive historical/archaeological/religious/national parks/sanctuary/ecological habitat are within 2 km distance from source is estimated.

- No – C3 = 0
- Yes – C3 = 5

Now calculate receptor factor C using C = (C1 × C2) + C3

Calculating additional high-risk element factor D

Pollution control measures the present and the required, in the area for large-scale, medium- and small-scale industries and also due to unorganized sector. It is cumulative of ETPs, CETPs, and unorganized waste disposal, which is gauged based on the status report for the last two years. This can be easily determined by the table given in the CEPI document. And for this purpose following definition of inadequate facilities is used.

Inadequate facilities $\geq$ 10% units deficient in terms of design/operation and maintenance of pollution control in case of small- and medium-scale industries OR > 2% units deficiency in terms of design/operation and maintenance of pollution control in case of large-scale industries or common facilities.

Calculation of the Sub-Index

After calculating A, B, C and D; calculate the sub index score as:

SCORE = (A + B + C + D)

Sub index scores to be calculated for each of the individual environmental components that is, Air Environment, Surface Water Environment, and Soil & Ground Water Environment separately.

Calculation of the Aggregated CEPI

The aggregated CEPI Score can be calculated as.

$$\textbf{CEPI} = i_m + \{(100 - i_m) \times (i_2/100) \times (i_3/100)\}$$

Where, i_m – maximum sub index; and i_2, and i_3 are sub indices for other media

Formula for calculating the final value of CEPI is illustrated in table below using some hypothetical values of sub-indices. These values have been chosen in a manner so as to bring out the most important characteristics of the aggregating method.

Industrial area/cluster	Air index	Water index	Land index	CEPI (rounded to next integer)
A	60.00	60.00	60.00	75
B	60.00	60.00	50.00	72
C	60.00	50.00	50.00	70
D	50.00	50.00	50.00	63

Common Problems in Estimating CEPI and Suggested Solutions

Some of the common problems faced while applying the proposed CEPI based on the above guidelines and its probable solutions are briefly described in the following paragraph.

Categorization of Industrial clusters

The analysis of the scoring algorithm used for estimating Sub-Index score shows that a score of more than 63 for an industrial cluster/ area shows a critical level of pollution in the respective environmental component, whereas a score between 51 – 63 shows a severe to critical level of pollution with reference to the respective environmental component. However, it is suggested to adopt a cut-off score of 50 and 60 for categorizing the industrial clusters/ areas into severely polluted and critically polluted industrial clusters/ areas respectively. The reason for marginally stringent cut-offs are, (i) to cover those clusters/ areas which are getting lower scores due to lack of data and (ii) to have rounded numbers as cut-offs.

Table 5 Problems and solutions in CEPI application

Factor	Problem	Solution
A1	Determining critical pollutants	An exhaustive classification of industrial pollutants into the groups A, B, and C
A2	Lack of classified data about industries present	SPCB/ industrial association/industry development corporations should classify industries based on R17 and R54
B1	• Lack of data especially for groundwater • Various data sets for surface water • Inconsistency in measurements within an area	• Maintenance of records with all local or state authorities • CETP effluents discharged should be preferably monitored • Proper and regular data collection drives at all points considered
B2, B3	Lack of evidence of adverse impact	Local health bodies/NGOs/legal authorities (PILs), and so on, should be contacted
C1	No data of population within 2 km of the source; also the definition of source is not clear	Consider total population to get a conservative value
C2	24 hours exceedence factor is not applicable for water and land pollution	Normal exceedence factor based on average annual data can be used
C3	No information about sensitive areas	ASI/IMA/municipal bodies to be involved

It is suggested that areas having aggregated CEPI scores of 70 and above should be considered as critically polluted areas, whereas the areas having CEPI between 60-70 should be considered as severely polluted areas and shall be kept under surveillance and pollution control measures should be efficiently implemented, whereas, the critically polluted clusters/ areas need detailed investigations in terms of the extent of damage and an appropriate remedial action plan.

The overall CEPI should be presented in the alpha-numeric form stating the score along with the status of Air, Water and Land environment in terms of subscript as critical/ severe/ normal. For example 78 AcWsLn denotes a overall score of 78 with Air environment having a score of more than 60 (critically polluted), water environment having score between 50-60 (severely polluted) and Land environment having a score of less than 50 (not polluted).

Chapter 4
Summary and conclusions

Through the course of this project, an attempt has been made to formulate, test, and improve an environmental tool to assess the pollution potential of industrial clusters/areas in India. Several existing methods and approaches were thoroughly studied and analysed before commencing the work on this project. Various issues, related to selection of variables and response functions, have been resolved by the brain storming workshop involving a group of experts while formulating comprehensive environmental pollution index (CEPI).

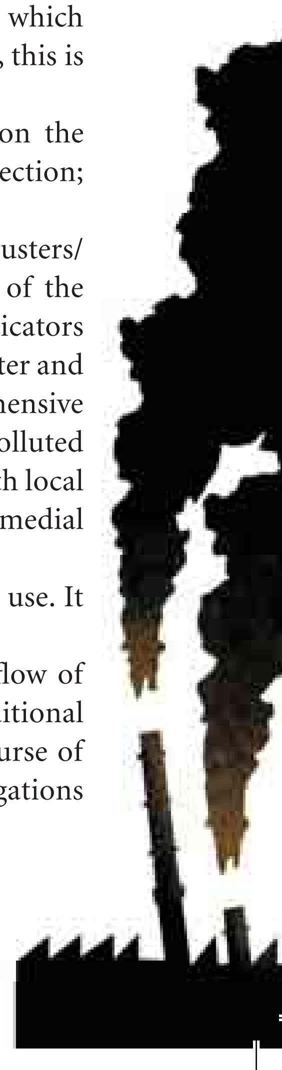
This index travelled a long way, from its initial, through constant testing and improvements. It provides a comprehensive tool for determining the environmental problems of industrial clusters/areas, which can further be used to improve the mitigation facilities in these industrial clusters/areas. The source-pathway-receptor approach was considered while formulating this tool, which covers the basic linkages in the ecological process as opposed to other existing indices. Also, this is easy to use and bars complex calculations.

Perfection in the process of CEPI application to industrial clusters/areas depends on the consistency in pollution data available, regular environmental monitoring for data collection; presence of evidences of adverse impact on human or ecology, and so on.

The present CEPI could be used for initial environmental assessment of the industrial clusters/areas based on ground information. Constant and intensive environmental surveillance of the polluted industrial clusters/areas should be done to assess the various environmental indicators and investigate the status of environmental resources including land, vegetation, air, and water and also a plan for remedial actions. It is further suggested that, as given in Step II a comprehensive analysis of spatial and temporal data/information shall be done for the identified polluted industrial clusters/areas. Action plans should be subsequently developed in consultation with local stakeholders, experts, and policy-makers. The outcome shall be used for preparing for remedial action plan.

The present CEPI is intended to act as an early sensor tool, which is easy and quick to use. It can help in categorizing the industrial clusters/areas in terms of priority.

The estimation of CEPI should be a dynamic and ongoing process and continuous flow of additional data and information in assessing CEPI should be ensured. It is suggested that additional information shall be collected and used corresponding to previous Steps as the future course of action. These industrial clusters/areas shall be subjected to detailed environmental investigations



for defining the spatial boundaries alongwith the extent of eco-geological damages. The outcome of further progressed Steps shall be used for preparing a comprehensive remedial action plan.

Step II involves a detailed assessment of various environmental indicators and investigation of the status of environmental resources such as land, vegetation, air, and water. Spatial and temporal variations in various environmental indicators shall be analysed and inferred for this purpose. The spatial and temporal data will help in ascertaining the extent of damage of the various environmental components and their rejuvenation by implementing necessary preventive and control measures.

A detailed action plan for pollution preventing, abatement and control as well as remediation of various environmental components, employing the green technology/modern technology and appropriate engineering practices, is the subsequent step (III). This step involves a detailed consultation and brainstorming in a hierarchical and structured manner with the various stakeholders, such as industry representatives, health experts, ecologists, local NGOs, technology experts, policy-makers, and regulatory agencies. A comprehensive implementation mechanism including financial, manpower, and technology shall be put to work in a time bound manner with an efficient monitoring mechanism.

REFERENCES

Ahlheim M and Fr¨Or O. 2005. **Constructing a preference-oriented index of environmental quality.** *Advances in Public Economics: Utility, Choice, and Welfare* Volume number (issue number): 151–172

Arunraj N S and Maiti J. 2009. **Development of environmental consequence index using fuzzy composite programming.** *Journal of Hazardous Materials* **162**: 29–43

Discoli Carlos A. 2005. **Urban environmental impact matrices development: assessment indices incorporation.** *Building and Environment* **40**: 915–928

EPA. 2005. ***EPA Practices for Identifying and Inventorying Hazardous Sites could assist similar Department of the Interior Efforts.*** Report No. 2005-P-00020

EPA. 2009. ***Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index.*** EPA-454/B-09-001
Details available at <http://www.cpcb.nic.in>
Details available at <http:// www.epa.gov/airnow>
Details available at <http://www.wikipedia.com>

Kang S M. 2002. **A sensitivity analysis of the Korean composite environmental index.** *Ecological Economics* **43**: 159–174

Marchini A, Facchinetti T, and Mistri M. 2009. **F-IND: a framework to design fuzzy indices of environmental conditions.** *Ecological Indicators* **9**: 485–496

Nunes C and Soares A. 2007. **Stochastic environmental research risk assessment.** *Ecological Modelling* **201**: 118–126

Pykh Yuri A, Kennedy E T, Grant W E. 2000. **An overview of systems analysis methods in delineating environmental quality indices.** *Ecological Modelling* **130**: 25–38

Schultink G. 2000. **Critical environmental indicators: performance indices and assessment models for sustainable rural development planning.** *Ecological Modelling* **130**: 47–58

Silvert W. 2000. **Fuzzy indices of environmental conditions.** *Ecological Modelling* **130**: 111–119

Sólnes Júlíus. 2003. **Environmental quality indexing of large industrial development alternatives using AHP.** *Environment Impact Assess. Rev* **23**: 283–303

Stigter T Y, Ribeiro L, and Carvalho Dill A M M. 2006. **Application of a groundwater quality index as an assessment and communication tool in agro-environmental policies – two Portuguese case studies.** *Journal of Hydrology* **327**: 578–591

Zhouv P, Ang B W, and Poh K L. 2006. **Comparing aggregating methods for constructing the composite environmental index: an objective measure.** *Ecological Economics* **59**: 305–311

Appendix 1

Group B: Probable human carcinogens

- Acrylamide
- Adriamycin
- Androgenic (anabolic) steroids
- Aristolochic acids (naturally occurring mixtures of)
- Azacitidine
- Bischloroethyl nitrosourea (BCNU)
- Captafol
- Chloramphenicol
- a-Chlorinated toluenes (benzal chloride, benzotrichloride, benzyl chloride) and benzoyl chloride (combined exposures)
- 1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
- 4-Chloro-ortho-toluidine
- Chlorozotocin
- Cisplatin
- Clonorchis sinensis (infection with)
- Cyclopenta[cd]pyrene
- Dibenz[a,h]anthracene
- Dibenzo[a,l]pyrene
- Diethyl sulfate
- Dimethylcarbamoyl chloride
- 1,2-Dimethylhydrazine
- Dimethyl sulfate
- Epichlorohydrin
- Ethyl carbamate (urethane)
- Ethylene dibromide
- N-Ethyl-N-nitrosourea
- Etoposide
- Glycidol
- Indium phosphide
- IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)
- Kaposi's sarcoma herpesvirus/human herpesvirus 8
- Lead compounds, inorganic
- 5-Methoxypsoralen
- Methyl methanesulfonate
- N-Methyl-N´-nitro-N-nitrosoguanidine(MNNG)
- N-Methyl-N-nitrosourea
- Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation
- Nitrogen mustard
- N-Nitrosodiethylamine
- N-Nitrosodimethylamine
- Phenacetin
- Procarbazine hydrochloride
- Styrene-7,8-oxide
- Teniposide
- Tetrachloroethylene
- Trichloroethylene
- 1,2,3-Trichloropropane
- Tris(2,3-dibromopropyl) phosphate
- Ultraviolet radiation A
- Ultraviolet radiation B
- Ultraviolet radiation C
- Urethane (ethyl carbamate)

- Vinyl bromide (Note: For practical purposes, vinyl bromide should be considered to act similarly to the human carcinogen vinyl chloride.)
- Vinyl fluoride (Note: For practical purposes, vinyl fluoride should be considered to act similarly to the human carcinogen vinyl chloride)
- PM_{10} and $PM_{2.5}$

Mixtures

- Creosotes
- Diesel engine exhaust
- High-temperature frying, emissions from
- Hot mate
- Household combustion of biomass fuel (primarily wood), indoor emissions
- Non-arsenical insecticides (occupational exposures in spraying and application)
- Polychlorinated biphenyls

Exposure circumstances

- Art glass, glass containers and pressed ware (manufacture)
- Carbon electrode manufacture
- Cobalt metal with tungsten carbide
- Hairdresser or barber (occupational exposure)
- Petroleum refining (occupational exposures)
- Shiftwork that involves circadian disruption
- Sunlamps and sunbeds (use of)

Source International Agency for Research on Cancer – 'Probably carcinogenic to humans' (Group 2A as per USEPA)

Appendix 2

Group C: Known human carcinogens

- 4-Aminobiphenyl
- Arsenic and arsenic compounds
- Asbestos
- Azathioprine
- Benzene
- Benzidine
- Benzo[a]pyrene
- Beryllium and beryllium compounds
- N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)
- Bis(chloromethyl)ether and chloromethyl methyl ether (technical-grade)
- 1,3-Butadiene
- 1,4-Butanediol dimethanesulfonate (Busulphan; Myleran)
- Cadmium and cadmium compounds
- Chlorambucil
- 1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU; Semustine)
- Chromium[VI]
- Ciclosporin
- Cyclophosphamide
- Diethylstilbestrol
- Dyes metabolized to benzidine
- Epstein-Barr virus
- Erionite
- Estrogen-progestogen menopausal therapy (combined)
- Estrogen-progestogen oral contraceptives (combined)
- Estrogens
- Estrogens, steroidal
- Estrogen therapy, postmenopausal
- Ethanol in alcoholic beverages
- Ethylene oxide
- Etoposide in combination with cisplatin and bleomycin
- Formaldehyde
- Gallium arsenide
- [Gamma Radiation: see X- and Gamma (g)-Radiation]
- Helicobacter pylori (infection with)
- Hepatitis B virus (chronic infection with)
- Hepatitis C virus (chronic infection with)
- Human immunodeficiency virus type 1 (infection with)
- Human papillomavirus types 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59 and 66 (Note: The HPV types that have been classified as carcinogenic to humans can differ by an order of magnitude in risk for cervical cancer)
- Human T-cell lymphotropic virus type I
- Melphalan
- 8-Methoxypsoralen (Methoxsalen) plus ultraviolet A radiation
- Methylenebis(chloroaniline) (MOCA)

- MOPP and other combined chemotherapy including alkylating agents
- Mustard gas (Sulphur mustard)
- 2-Naphthylamine
- Neutrons
- Nickel compounds
- N'-Nitrosonornicotine (NNN) and 4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK) Opisthorchis viverrini (infection with)
- [Oral contraceptives, combined estrogen-progestogen: see Estrogen-progestogen oral contraceptives (combined)]
- Oral contraceptives, sequential
- Phosphorus-32, as phosphate
- Plutonium-239 and its decay products (may contain plutonium-240 and other isotopes), as aerosols
- Radioiodines, short-lived isotopes, including iodine-131, from atomic reactor accidents and nuclear weapons detonation (exposure during childhood)
- Radionuclides, a-particle-emitting, internally deposited (Note: Specific radionuclides for which there is sufficient evidence for carcinogenicity to humans are also listed individually as Group 1 agents)
- Radionuclides, b-particle-emitting, internally deposited (Note: Specific radionuclides for which there is sufficient evidence for carcinogenicity to humans are also listed individually as Group 1 agents)
- Radium-224 and its decay products
- Radium-226 and its decay products
- Radium-228 and its decay products
- Radon-222 and its decay products
- Schistosoma haematobium (infection with)
- Silica, crystalline (inhaled in the form of quartz or cristobalite from occupational sources)
- Solar radiation
- Talc containing asbestiform fibres
- Tamoxifen (Note: There is also conclusive evidence that tamoxifen reduces the risk of contralateral breast cancer)
- 2,3,7,8-Tetrachlorodibenzo-para-dioxin
- Thiotepa
- Thorium-232 and its decay products, administered intravenously as a colloidal dispersion of thorium-232 dioxide
- ortho-Toluidine
- Treosulfan
- Vinyl chloride
- X- and Gamma (g)-radiation

Mixtures

- Aflatoxins (naturally occurring mixtures)
- Alcoholic beverages
- Areca nut
- Betel quid with tobacco
- Betel quid without tobacco
- Coal-tar pitches
- Coal-tars
- Herbal remedies containing plant species of the genus Aristolochia
- Household combustion of coal, indoor emissions
- Mineral oils, untreated and mildly treated
- Phenacetin, analgesic mixtures
- Salted fish (Chinese-style)
- Shale-oils
- Soots
- Tobacco, smokeless
- Wood dust

Exposure circumstances

- Aluminum production
- Arsenic in drinking-water
- Auramine production
- Boot and shoe manufacture and repair
- Chimney sweeping
- Coal gasification
- Coal-tar distillation
- Coke production
- Furniture and cabinet making
- Hematite mining (underground) with exposure to radon
- Involuntary smoking (exposure to secondhand or 'environmental' tobacco smoke)
- Iron and steel founding
- Isopropyl alcohol manufacture (strong-acid process)
- Magenta production
- Painter (occupational exposure as a)
- Paving and roofing with coal-tar pitch
- Rubber industry
- Strong-inorganic-acid mists containing sulphuric acid (occupational exposure)
- Tobacco smoking and tobacco smoke

Source International Agency for Research on Cancer 'Carcinogenic to humans' (Group 1).

Appendix 3

List of 17 categories of highly polluting industries

1 Aluminium smelting
2 Basic drugs and pharmaceuticals manufacturing
3 Caustic soda
4 Cement (200 tonnes per day (TPD) and above)
5 Copper smelting
6 Dyes and dye intermediate
7 Fermentation (distillery)
8 Fertilizer
9 Integrated iron and steel
10 Leather processing including tanneries
11 Oil refinery
12 Pesticide formulation and manufacturing
13 Pulp and paper (30 TPD and above)
14 Petrochemical
15 Sugar
16 Thermal power
17 Zinc smelting

Appendix 4

List of the 54 red categories

1 Anodizing
2 Asbestos and asbestos based industries
3 Automobiles Manufacturing/assembling
4 Ceramic/refractories
5 Chemical, petrochemical and electro chemicals including manufacture of acids such as sulphuric acid, nitric acid, phosphoric acid, and so on
6 Cholrates, perchlorates, and peroxides
7 Cholrine, fluorine, bromine, iodine, and their compounds
8 Coke making, coal liquefaction, coaltar distillation or fuel gas making
9 Common effluent treatment plant
10 Dry coal processing/mineral processing industries like ore sintering, palletisation, and so on
11 Explosives including detonatros, fuses, and so on
12 Fermentation industry including manufacture of yeast, beer, and so on
13 Fire crackers
14 Foundries
15 Glass and fibre glass production and processing (excluding moulding)
16 Glue and gelatin
17 Heavy, engineering
18 Hospitals
19 Hot mix plants
20 Hydrocyanic acid and its derivatives
21 Incineration plants
22 Industrail carbon including electrodes and graphite blocks, activated carbon, carbon black, and so on
23 Industrail or inorganic gases namely (a) chemical gases: acetylene, hydrogen, chlorine, fluorine, ammonia, sulphur dioxide, ethylene, hydrogen sulphide, phosphine, (b) hydrocarbon gases: methane, butane, ethane, propane
24 Industry or process involving electroplating operations
25 Industry or process involving foundry operations
26 Industry or process involving metal treatment or process such as pickling, paint stripping, heat treatment, phosphating or finishing, and so on
27 Lead re-processing and manufacturing including lead smelting
28 Lime manufacturing
29 Lubricating oils, greases or petroleum-based products
30 Milk processing and dairy products (integrated project)
31 Mining and ore-beneficiation
32 Organic chemical manufacturing
33 Parboiled rice mills

34 Paints and varnishes (excluding blending/mixing)
35 Petroleum products manufacturing and oil/crude oil/residues reprocessing
36 Phosphate rock processing plants
37 Phosphorous and its compounds
38 Photographic films and chemicals
39 Pigments and intermediates
40 Potable alcohol (IMFL) by blending or distillation of alcohol
41 Power generating plants (excluding DG sets)
42 Processes involving chlorinated hydrocarbons
43 Ship breaking
44 Slaughter houses and meat processing industries
45 Steel and steel products including coke plants involving use of any of the equipment's such as blast furnaces, open furnace, induction furnace or an arc furnace and so on, or any of the operations or processes such as heat treatment, acid pickling, roiling or galvanizing, and so on
46 Stone crushers
47 Surgical and medical products involving prophylactics and latex
48 Synthetic detergent and soap
49 Synthetic fibre including rayon, tyre cord, polyester filament yarn
50 Synthetic resins
51 Synthetic rubber excluding moulding
52 Tobacco products including cigarettes and tobacco processing
53 Vegetable oils including solvent extracted oils, hydrogenated oils
54 Yarn and textile processing involving scouring, bleaching, dyeing, printing or any effluent/emission-generating process

Appendix 5

Environmental standards

A Ambient air quality standards

रजिस्ट्री सं. डी.एल.-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र

The Gazette of India

असाधारण

EXTRAORDINARY

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PART III—Section 4

प्राधिकार से प्रकाशित

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राष्ट्रीय परिवेशी वायु गुणवत्ता मानक

केन्द्रीय प्रदूषण नियंत्रण बोर्ड

अधिसूचना

नई दिल्ली, 18 नवम्बर, 2009

सं. बी-29016/20/90/पी.सी.आई.-I—वायु (प्रदूषण निवारण एवं नियंत्रण) अधिनियम, 1981 (1981 का 14) की धारा 16 की उपधारा (2) (एच) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए तथा अधिसूचना संख्या का.आ. 384(ई), दिनांक 11 अप्रैल, 1994 और का.आ. 935 (ई) दिनांक 14 अक्तूबर, 1998 के अधिक्रमण में केन्द्रीय प्रदूषण नियंत्रण बोर्ड इसके द्वारा तत्काल प्रभाव से राष्ट्रीय परिवेशी वायु गुणवत्ता मानक अधिसूचित करता है, जो इस प्रकार है-

राष्ट्रीय परिवेशी वायु गुणवत्ता मानक

क्र. सं.	प्रदूषक	समय-आधारित औसत	परिवेशी वायु में सान्द्रण		
			औद्योगिक, रिहायशी, ग्रामीण और अन्य क्षेत्र	पारिस्थितिकीय रूप से संवेदनशील क्षेत्र (केन्द्र सरकार द्वारा अधिसूचित)	प्रबोधन की पद्धति
(1)	(2)	(3)	(4)	(5)	(6)
1	सल्फर डाई आक्साइड (SO_2), µg/m³	वार्षिक* 24 घंटे**	50 80	20 80	-उन्नत वेस्ट और गाईक -पराबैंगनी परिदीप्ति
2	नाइट्रोजन डाई आक्साइड (NO_2), µg/m³	वार्षिक* 24 घंटे**	40 80	30 80	-उपांतरित जैकब और हॉचाइजर (सोडियम-आर्सेनाइट) -रसायनिक संदीप्ति
3	विविक्त पदार्थ (10 माइक्रान से कम आकार) या PM_{10}, µg/m³	वार्षिक* 24 घंटे**	60 100	60 100	-ग्रावमैट्रिक विश्लेषण -टीयम -बीटा तनुकरण पद्धति

3487 GI/2009 (1)

4	विविक्त पदार्थ (2.5 माइक्रान से कम आकार या $PM_{2.5}$, $\mu g/m^3$	वार्षिक* 24 घंटे**	40 60	40 60	-हरात्मक विश्लेषण -टेयोम -बीटा तनुकरण पद्धति
5	ओज़ोन (O_3) $\mu g/m^3$	8 घंटे** 1 घंटा**	100 180	100 180	-पराबैंगनी द्वीप्तिकाल -रासायनिक संदीप्ति -रासायनिक पद्धति
6	सीसा (Pb) $\mu g/m^3$	वार्षिक* 24 घंटे**	0.50 1.0	0.50 1.0	ई.पी.एम 2000 या समरूप फिल्टर पेपर का प्रयोग करके AAS/ICP पद्धति -टेफलॉन फिल्टर पेपर का प्रयोग करते हुए ED-XRF
7	कार्बन मोनोक्साइड (CO) mg/m^3	8 घंटे** 1 घंटा**	02 04	02 04	-अविक्षेपी अवरक्त (NDIR) स्पैक्ट्रम मापन
8	अमोनिया (NH_3) $\mu g/m^3$	वार्षिक* 24 घंटे**	100 400	100 400	-रासायनिक संदीप्ति -इण्डोफिनॉल ब्लू पद्धति
9	बैन्ज़ीन (C_6H_6) $\mu g/m^3$	वार्षिक*	05	05	– गैस क्रोमेटोग्राफी आधारित सतत् विश्लेषक -अधिशोषण तथा विशोषण के बाद गैस क्रोमेटोग्राफी
10	बैन्ज़ो (ए) पाईरीन (BaP) केवल विविक्त कण, ng/m^3	वार्षिक*	01	01	-विलायक निष्कर्षण के बाद HPLC/GC द्वारा विश्लेषण
11	आर्सैनिक (As) ng/m^3	वार्षिक*	06	06	-असविलरक अवरक्त स्पैक्ट्रमिती ई.पी.एम. 2000 या समरूप फिल्टर पेपर का प्रयोग करके ICP/AAS पद्धति
12	निकिल (Ni) ng/m^3	वार्षिक*	20	20	ई.पी.एम. 2000 या समरूप फिल्टर पेपर का प्रयोग करके ICP/AAS पद्धति

* वर्ष में एक समान अंतरालों पर सप्ताह में दो बार प्रति 24 घंटे तक किसी एक स्थान विशेष पर लिये गये न्यूनतम 104 मापों का वार्षिक अंकगणीतीय औसत ।

** वर्ष में 98 प्रतिशत समय पर 24 घंटे या 8 घंटे या 1 घंटा के मानीटर मापमान, जो लागू हो, अनुपालन किये जाएंगे । दो प्रतिशत समय पर यह मापमान अधिक हो सकता है, किन्तु क्रमिक दो मानीटर करने के दिनों पर नहीं ।

टिप्पणी।

1. जब कभी और जहां भी किसी अपने-अपने प्रवर्ग के लिये दो क्रमिक प्रबोधन दिनों पर मापित मूल्य, उपर विनिर्दिष्ट सीमा से अधिक हो तो इसे नियमित या निरंतर प्रबोधन तथा अतिरिक्त अन्वेषण करवाने के लिये पर्याप्त कारण समझा जायेगा ।

संत प्रसाद गौतम, अध्यक्ष

[विज्ञापन-III/4/184/09/असा.]

टिप्पणी। राष्ट्रीय परिवेशी वायु गुणवत्ता मानक संबंधी अधिसूचनाएँ, केन्द्रीय प्रदूषण नियंत्रण बोर्ड द्वारा भारत के राजपत्र असाधारण में अधिसूचना संख्या का.आ. 384 (ई), दिनांक 11 अप्रैल, 1994 एवं का. आ. 935 (ई), दिनांक 14 अक्टूबर, 1998 द्वारा प्रकाशित की गयी थी ।

NATIONAL AMBIENT AIR QUALITY STANDARDS
CENTRAL POLLUTION CONTROL BOARD
NOTIFICATION
New Delhi, the 18th November, 2009

No. B-29016/20/90/PCI-I.—In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No.14 of 1981), and in supersession of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely:-

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m³	Annual* 24 hours**	50 80	20 80	- Improved West and Gaeke -Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m³	Annual* 24 hours**	40 80	30 80	- Modified Jacob & Hochheiser (Na-Arsenite) - Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m³	Annual* 24 hours**	60 100	60 100	- Gravimetric - TOEM - Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m³	Annual* 24 hours**	40 60	40 60	- Gravimetric - TOEM - Beta attenuation
5	Ozone (O_3) µg/m³	8 hours** 1 hour**	100 180	100 180	- UV photometric - Chemiluminescence - Chemical Method
6	Lead (Pb) µg/m³	Annual* 24 hours**	0.50 1.0	0.50 1.0	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
7	Carbon Monoxide (CO) mg/m³	8 hours** 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) spectroscopy
8	Ammonia (NH_3) µg/m³	Annual* 24 hours**	100 400	100 400	-Chemiluminescence -Indophenol blue method

(1)	(2)	(3)	(4)	(5)	(6)
9	Benzene (C_6H_6) µg/m^3	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(o)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note. — Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

SANT PRASAD GAUTAM, Chairman
[ADVT-III/4/184/09/Exty.]

Note: The notifications on National Ambient Air Quality Standards were published by the Central Pollution Control Board in the Gazette of India, Extraordinary vide notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998.

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and Published by the Controller of Publications, Delhi-110054.

B General standards for discharge of environment pollutants: effluent

S. No.	Parameter	Standards Inland surface water (a)	Public sewers (b)	Land for irrigation (c)	Marine coastal areas (d)
1.	Colour and odour	—	—	—	—
2.	Suspended solids mg/l, Max.	100	600	200	a) For process waste water-100 b) For cooling water effluent 10 percent above total suspended matter of influent
3.	Particular size of suspended solids	Shall pass 850 micron IS Sieve	—		a) Floatable solids, max. 3 mm b) Settleable solids, max 850 microns
4.	***	*	—	***	—
5.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6.	Temperature	Shall not exceed 5 °C above the receiving water temperature	—	—	Shall not exceed 5 °C above the receiving water temperature
7.	Oil and grease mg/l Max.	10	20	10	20
8.	Total residual chlorine mg/l Max.	1.0	—	—	1.0
9.	Ammonical nitrogen (as N), mg/l Max.	50	50	—	50
10.	Total Kjeldahl nitrogen (as NH3) mg/l, Max	100	—	—	100
11.	Free ammonia (as NH_3) mg/l, Max	5.0	—	—	5.0
12.	Biochemical oxygen demand (5 days at 20 °C) mg/l Max.	30	350	100	100
13.	Chemical oxygen demand, mg/l Max.	250	—	—	250

S. No.	Parameter	Standards Inland surface water (a)	Public sewers (b)	Land for irrigation (c)	Marine coastal areas (d)
14.	Arsenic (as As), mg/l Max.	0.2	0.2	0.2	0.2
15.	Mercury (As Hg) mg/l Max.	0.01	0.01	—	0.01
16.	Lead (as Pb) mg/l, Max.	0.1	1.0	—	2.0
17.	Cadmium (as Cd) mg/l, Max.	2.0	1.0	—	2.0
18.	Hexavalent chromium (as Cr+6), mg/l, Max.	0.1	2.0	—	2.0
19.	Total chromium (as Cr) mg/l, Max.	2.0	2.0	—	2.0
20.	Copper (as Cu) mg/l, Max.	3.0	3.0	—	3.0
21.	Zinc (as Zn.) mg/l Max.	5.0	15	—	15
22.	Selenium (as Se) mg/l, Max.	0.05	0.05	—	0.05
23.	Nickel (as Ni) mg/l, Max.	3.0	3.0	—	5.0
24.	***	*	*	*	*
25.	***	*	*	*	*
26.	***	*	*	*	*
27.	Cyanide (as CN) mg/l Max.	0.2	2.0	0.2	0.2
28.	***	*	*	*	*
29.	Fluoride (as F) mg/l Max.	2.0	15	—	15
30.	Dissolved phosphates (as P), mg/l Max.	5.0	—	—	—

S. No.	Parameter	Standards Inland surface water (a)	Public sewers (b)	Land for irrigation (c)	Marine coastal areas (d)
31.	***	*	*	*	*
32.	Sulphide (as S) mg/l Max.	2.0	—	—	5.0
33.	Phenolic compounds (as C_6H_5OH) mg/l Max.	1.0	5.0	—	5.0
34.	Radioactive materials (a) Alpha emitter micro curie/ml	10–7	10–7	10–8	10–7
	(b) Beta emitter micro curie/ml	10–6	10–6	10–7	10–6
35.	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
36.	Manganese (as Mn) mg/l	2	2	—	2
37.	Iron (as Fe) mg/l	3	3	—	3
38.	Vanadium (as V)	0.2	0.2	—	0.2
39.	Nitrate Nitrogen mg/l	10	—	—	20
40.	***	*	*	*	*

1 Schedule : VI inserted by Rule 2(d) of the Environment (Protection), Second Amendment Rules, 1993 notified vide G.S.R. 422(E) dated 19.05.1993, published in the Gazette No. 174 dated 19.05.1993.

2 Omitted by Rule 2(d)(i) of the Environment (Protection) Third Amendment Rules, 1993 vide Notification No. G.S.R. 801 (E) dated 31.12.1993

C. Water-Quality Parameters-Requirements & Classification:

Water quality parameters are classified into three categories, given in Table (i), (ii) and (iii) (Source: CPCB, 2002, "Water Quality Criteria and Goals", Monitoring of Indian National aquatic Resources Series: MINARS/17/2001-2002).

Table: Basic Water-Quality Requirements & Classification (Surface Water + Ground Water)

(i) Simple Parameters

S. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	B-Desirable	C-Acceptable
(i)	Sanitary Survey	Very Clean neighbourhood and catchment	Reasonably clean neighbourhood	Generally clean neighbourhood
(ii)	General Appearance	No floating matter	No floating matter	No floating matter
(iii)	Colour	Absolutely Colourless	Almost colourless, very light shade if any	No colour of anthropogenic origin
(iv)	Smell	Odourless	Almost odourless	No unpleasant odour
(v)	Transparency	>1.0 depth	>0.5 to 0.1m depth	>0.2 to 0.5 m depth
(vi)	Ecological* (Presence of Animals)	Fish & Inspects	Fish & Inspects	Fish & Inspects

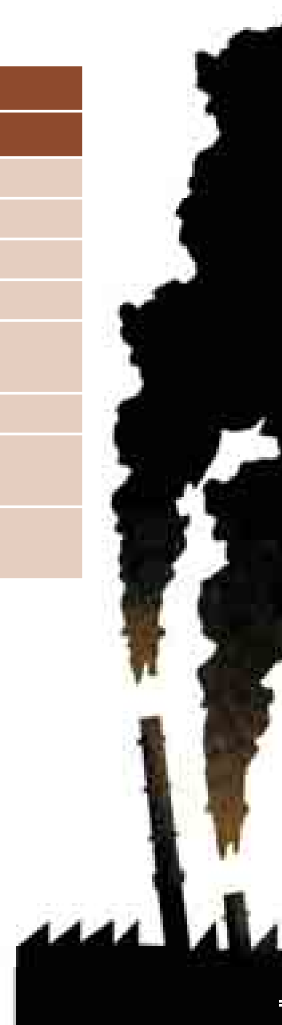
* Applicable to only surface water

(ii) Regular Monitoring Parameters

S. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	B-Desirable	C-Acceptable
(i)	pH	7.0 to 8.5	6.5 to 9.0	6.5 to 9.0
(ii)	DO (% Saturation)	90-110	80-120	60-140
(iii)	BOD, mg/l	Below 2	Below 5	Below 8
(iv)	EC, µmhos/cm	<1000	<2250	<4000
(v)	(NO_2+NO_3)-Nitrogen, mg/l	<5	<10	<15
(vi)	Suspended solid, mg/l	<25	<50	<100
(vii)	Fecal Coliform, MPN/ 100 ml	<20 per 100 ml	<200 per 100 ml	<2000 per 100 ml
(viii)	Bio-assay (Zebra Fish)	No death in 5 daysv	No death in 3 days	No death in 2 days

Note:

1 Dissolved Oxygen (DO) not applicable for ground waters.
2 Dissolved Oxygen in eutrophicated waters should include measurement for diurnal variation
3 Suspended solid limit is applicable only during non-monsoon period.
4 Fecal Coliform values should meet for 90% times.
5 Static Bio-Assay method may be adopted.



(iii) Special Parameters: (Only in cases of need/ apprehensions)

S. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	B-Desirable	C-Acceptable
(i)	Total Phosphorous	<0.1 mg/l	< 0.2 mg/l	< 0.3 mg/l
(ii)	T.K.N	< 1.0 mg/l	<2.0 mg/l	<3.0 mg/l
(iii)	Total Ammonia (NH_4 + NH_3)-Nitrogen	< 0.5 mg/l	< 1.0 mg/l	< 1.5 mg/l
(iv)	Phenols	< 2µg/l	< 5µg/l	<10 µg/l
(v)	Surface Active Agents	<20 µg/l	<100µg/l	< 200µg/l
(vi)	Organo Chlorine Pesticides	< 0.05µg/l	< 0.1µg/l	< 0.2µg/l
(vii)	PAH	< 0.05µg/l	<0.1 µg/l	<0.2 µg/l
(viii)	PCB and PCT	< 0.01µg/l	< 0.01µg/l	< 0.02µg/l
(ix)	Zinc	< 100µg/l	< 200µg/l	<300 µg/l
(x)	Nickel	< 50µg/l	< 100µg/l	< 200µg/l
(xi)	Copper	< 20µg/l	< 50µg/l	<100µg/l
(xii)	Chromium (Total)	< 20µg/l	< 50µg/l	< 100µg/l
(xiii)	Arsenic (Total)	< 20µg/l	<50 µg/l	<100 µg/l
(xiv)	Lead	< 20µg/l	< 50µg/l	< 100µg/l
(xv)	Cadmium	< 1.0µg/l	<2.5 µg/l	< 5.0µg/l
(xvi)	Mercury	< 0.2µg/l	< 0.5µg/l	< 1.0µg/l

Appendix 6
Exceedence factor calculation

The ambient environmental (ambient air/surface water/ground water) quality has been categorized into four broad categories based on an exceedence factor (the ratio of annual (or 24-hour) mean concentration of a pollutant with that of a respective standard). The Exceedence Factor (EF) is calculated as follows:

$$\text{Exceedence factor} = \frac{\text{Observed mean concentration of criteria pollutant}}{\text{Prescribed standard for the respective pollutant and area class}}$$

The four environmental quality categories are:
- Critical pollution (C): when EF is more than 1.5;
- High pollution (H): when the EF is between 1.0 and 1.5;
- Moderate pollution (M): when the EF between 0.5 and 1.0; and
- Low pollution (L): when the EF is less than 0.5.

Appendix 7

Participants of the 'Workshop on Development of Environmental Pollution Index (EPI) for Industrial Clusters/Areas' (24 October 2009)

S. No.	Name	Organization of participants
1.	Prof. M Khare	IIT Delhi
2.	Dr Arvind K Nema	IIT Delhi
3.	Shri A K Vidyarthi	Environmental Engineer, CPCB
4.	Shri R K Suri	Additional Director, MoEF
5.	Shri R N Jindal	Additional Director, MoEF
6.	Dr Prateek Sharma	Dean (Applied Sciences), TERI University
7.	Mr Sanjeev Kanchan	Centre for Science and Environment
8.	Ms Anjali Gupta	Research Scholar, IIT Delhi
9.	Dr C V Chalpati Rao	Scientist, NEERI
10.	Dr Shiva Nagendra	Assistant Professor, IIT Madras
11.	Ms Reena Kumari Satwan	Asst. Env. Engineer, CPCB
12.	Ms Mayuri Chabukdhara	Research Scholar, IIT Delhi
13.	Dr D.D. Basu	Senior Scientist, CPCB
14.	Dr Manju Mohan	Professor, IIT Delhi
15.	Dr Suresh Jain	Assistant Professor, TERI University
16.	Dr Ragini Kumar	Toxic Links, NGO, Delhi
17.	Mr Sumantha Chinthala	Research Scholar, IIT Delhi
18.	Dr S K Singh	Professor, Delhi College of Engineering
19.	Mr Paritosh Kumar	Senior Environment Engineer, CPCB
20.	Dr Pramila Goel	Professor, IIT Delhi
21.	Mr Amit Munjal	M Tech student, IIT Delhi
22.	Dr A P Singh	Assistant Dean, BITS Pilani
23.	Mr Lalit M Pandey	Assistant Environment Engineer, CPCB
24.	Dr Aishwarya Vidyasagaran	PHFI
25.	Mr Raman Sharma	Research Scholar, IIT Delhi

26.	Dr A K Gupta	IIT Kharagpur
27.	Dr B J Alappat	IIT Delhi
28.	Mr R C Saxena	Senior Environment Engineer, CPCB
29.	Mr Sumit Malhotra	PHFI
30.	Mr Sanjay Gupta	Lab Superintendent, IIT Delhi
31.	Prof. Vinod Tare	IIT Kanpur
32.	Dr N N Rao	Scientist, NEERI
33.	Mr Keyur Singh	Environment Engineer, CPCB
34.	Mr Irfan Khurshed Shah	Research Scholar, IIT Delhi
35.	Dr B R Gurjar	IIT Roorkee
36.	Prof. S C prasad	MNIT Allahabad
37.	Ms Reeta Roy Chaudhary	JD, FICCI
38.	Ms Sweta Chauhan	M Tech Student, DCE
39.	Mr Gopi	M Tech Student, IIT Delhi

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BANGALORE

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A-Block, Thimmaiah Main Road, 7th D Cross
Shivanagar, Opp. Pushpanjali Theatre
Bangalore – 560 010
Tel. 080-23233827 (O)
080-23233739/
23233827/23233996
Fax 080-23234059

KOLKATA

Southernd Conclave
Block 502, 5th & 6th Floors, 582 Rajdanga,
Main Road, Kolkata – 700 107
Tel. 033-2441 6332(Direct)
033-2441 4289 / 4677 / 6003 / 6634
Fax 033-24418725

SHILLONG

TUM-SIR
Lower Motinagar
Near Fire Brigade H.Q.
Shillong – 793 014
Tel. 0364-2520923
0364-2522859
Fax 0364-2520805

BHOPAL

3rd Floor, Sahkar Bhawan
North TT Nagar, Bhopal – 462 003
Tel. 0755- 2775587 (O)
2775385/86 (PABX)
Fax 0755- 2775587

LUCKNOW

Ground Floor, PICUP Bhawan, Vibhuti Khand
Gomti Nagar, Lucknow – 226 010
Tel. 0522-4087601
0522-2721915/16
0522-4087600 (EPABX)
Fax 0522-2721891

VADODARA

Parivesh Bhawan
Opp. VMC Ward Office No. 10
Subhanpura, Vadodara – 390 023
Tel. 0265-2283226
0265-2283245
Fax 0265-2283294

AGRA PROJECT OFFICE

4, Dholpur house, M.G Road
Agra – 282 001
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