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Research Article

APPLICATION OF A GOAL PROGRAMMING MODEL TO OPTIMIZE QUANTITY OF AIR POLLUTANTS

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ABSTRACT
With the increase in quantity of pollutants in air, there is a rise in number of respiratory ailments. Pollution of air has become a global problem and is affecting all the sections of society, whether it is rural, sub- urban or urban. A number of pollutants rising either due to human activities or natural causes are identified along with their ill effects. Some of them are as: Carbon dioxide (CO_2), sulphur dioxide (SO_2), oxides of Nitrogen (NO_2), Chloro fluoro carbons (CFC), Suspended particulate matter (SPM), etc. Natural causes are generally neglected due to their very low frequency of occurrence and human inability to control them. But human activities are continuously affecting the quality of air and their frequency of occurrence is also increasing rapidly. Apart from this some control can be imposed on them by sincere human efforts.
In this paper our aim is to apply a goal programming optimization model which may be proved helpful in decision making while considering the priorities during the quantitative study of some major air pollutants striking our atmosphere.

Key Words: *Goal Programming, Optimization*

INTRODUCTION
In this modern and developing age, cities are fastly turning into gas chambers with the advent of more and more technological innovations (Jes, 1999, CPCB, 2000, Devi, Dahiya, Gadgil, Singh, Kumar, 2007). There is no boundary or limitation for air due to which amount of air pollution moves quickly and affects the far off areas. It is highly variable type of pollution as keep changing with time, place and conditions. There are a number of sources responsible for pollution in our space but some of major sources are Industries, thermal power plants, vehicles and domestic emissions (burning of coal, kerosene, wood in our houses restaurants etc.). We cannot stop emission of pollutants from these sources completely as these are synonyms of development. But we can impose some restrictions on these by adopting some measures which are eco- friendly and also not interrupt process of development like reduce- reuse- recycle, use of electrostatic precipitators, etc.
Government has set standards about emission of different pollutants and it is our responsibility to remain behind those lines of demarcation.
This paper suggests application of a goal programming model so that we may be able to remain sufficiently behind government limitations and help to control air pollution.

AIR POLLUTION AND GOAL PROGRAMMING
Air is a sustainable resource and introduction of any kind of foreign material which may alter the quality of air is called air pollution. Some of the major pollutants prevalent in Indian space are Carbon dioxide (CO_2), sulphur dioxide (SO_2), oxides of Nitrogen (NO_X), Total Suspended particulate matter (TSPM).
Sulphur dioxide (SO_2)
It is a qualitative pollutant that is its presence in any quantity is injurious. Its major sources are combustion of coal and oil, rubber vulcanization plants and chemical industries.

Carbon dioxide (CO_2)

It is a quantitative pollutant which means its presence in the atmosphere is essential but if the quantity exceeds a certain quantity it will be considered as a pollutant. It is produced by combustion of carbon compounds, respiration by humans and other animals.

Oxides of Nitrogen (NO_X)

These are quantitative pollutants and are produced due to burning of coal, gas, oil, gasoline, etc. when combustion temperatures are very high, from chemical industries.

Total Suspended Particulate Matter (TSPM)

This in ambient air is a complx multi phase system consisting of particle sizes ranging from less than 0.01 μm to more than 100 μm (Wan Kun *et al.*, (2006) and Devi, Dahiya, Gadgil, Singh, Kumar, 2007). It is a quantitative pollutant which is produced from soil, plants and different human activities in different forms.

C.P.C.B. Standards

The Central Pollution Control Boards has laid standards for control of air pollution in the Indian space.

Pollutant Area	Industrial Area	Residential Area	Sensitive Area
SO_2	80μg / m^3	60 μg / m^3	15 μg / m^3
NO_X	80 μg / m^3	60 μg / m^3	15 μg / m^3
CO	10 μg / m^3	4.0 μg / m^3	2.0 μg / m^3
TSPM	360 μg / m^3	140 μg / m^3	70 μg / m^3

Goal Programming

Goal programming was firstly introduced by Charnes and Cooper in the year 1961 and was further developed by Ignizio, Lee, Romero, etc. It is the technique of optimization of a number of goals and their multiple sub goals simultaneously.

Goal Programming is a fancy name for a very simple idea: the line between objectives and constraints is not completely solid. In particular, when there are a number of objectives, it is normally a good idea to treat some or all of them as constraints instead of objectives.

The only difference between linear programming and goal programming is that goal programming is multi dimensional in nature. Goal programming is the achieving the multiple goal simultaneously. In the linear programming the max/min function is set for only one quantity to control on its optimum value. Goal programming carries many goals related to each other and they have to be achieved. In this the minimum and maximum deviation are also set for the achieving the goal. Goals are arranged in an order according to priority which helps to minimize the deviations between the achievement and aspiration levels.

PRIORITY STRUCTURE

Priority 1: Reduction in levels of SO_2, CO_2, NO_X and TSPM

Goal (i): Minimize total amount of pollutants released by vehicles.

Goal (ii): Minimize total amount of pollutants released from industries.

Goal (iii): Minimize total amount of pollutants released from thermal power plants.

Goal (iv): Minimize total amount of pollutants released from domestic combustion.

GOAL PROGRAMMING MODEL

Min. $P_1 (d_1^-, d_2^-, d_3^-, d_4^-)$

Subject to:

1) Pollutant reduction goal

$\sum A_{vij} X_j = b_j + d_1^+ - d_1^-$ ……………………. (G1)

$Vij = i^{th}$ vehicle releasing j^{th} pollutant.

$\sum A_{Iij} X_j = b_j + d_2^+ - d_2^-$ ……………………… (G2)
Iij = i^{th} industry releasing j^{th} pollutant.
$\sum A_{Tij} X_j = b_j + d_3^+ - d_3^-$ …………………….. (G3)
Tij = i^{th} thermal power plant releasing j^{th} pollutant.
$\sum A_{Dij} X_j = b_j + d_4^+ - d_4^-$ …………………….. (G4)
Dij = i^{th} domestic activity releasing j^{th} pollutant.

2) Natural resource conservation Goal

$\sum A_{Wij} D^W{}_j = \chi^W{}_j - d_5^+ + d_5^-$ ………………… (G5)
$\sum A_{edij} D^{ed}{}_j = \chi^{ed}{}_j - d_6^+ + d_6^-$ ………………… (G6)
$\sum A_{aij} D^a{}_j = \chi^a{}_j - d_7^+ + d_7^-$ ………………… (G7)
A_{Wij}, A_{edij}, A_{aij} = Marginal contribution of decision variables.
$D^W{}_j$, $D^{ed}{}_j$, $D^a{}_j$ = Decision variables.
$\chi^W{}_j$, $\chi^{ed}{}_j$, $\chi^a{}_j$ = Aspiration level for j^{th} goal.
d_i^+ = positive deviation from the aspiration level.
d_i^- = negative deviation from the aspiration level.

CONCLUSION

Air pollution is highly dynamic in nature and it is really difficult to talk about the quality of air in a certain region for a long span of time. The model can be helpful for the environmentalists in determination and achievement of environmental goals, thus making our space clean enough to breathe freely. This paper presents a set of air pollution planning parameters along with optimization approach that may be used to make our air safer and achieve CPCB targets. It is quite possible that the decision variables presented here satisfy all the possible factors responsible for any change in the decision variables. Hence the model is a basic approach for any case study.

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