

Haze layer over the Indian Ocean – natural or anthropogenic?

Following the release of United Nations Environmental Program (UNEP) report¹, several reports have appeared in both print and electronic media raising concerns about the regional and/or global impacts of the haze layer (the so-called Asian Brown Cloud in UNEP report) that develops over South Asia during the January–April period. The UNEP press release² raises some alarm on the impacts of haze layer on the health, agriculture and climate on both the regional and global scales. Srinivasan and Gadgil³ have addressed several issues raised in the report and conclude that while ‘the news release has created awareness about the pollution’ that ‘should give an impetus to the ongoing program of reduction of harmful emissions in our cities’, there is no scientific basis for ‘the immediate and catastrophic consequences of the haze on the monsoon and agriculture’ as implied in the UNEP news release.

The UNEP report is based on the findings of an international experiment, called the Indian Ocean Experiment (INDOEX) conducted during 1998–2000 over the northern Indian Ocean. Most of the scientific results of the experiment are described in special volumes of *Current Science* [1999, **76** and 2001, **80** (supplement)] and *Journal of Geophysical Research* [2001, **106** (D22) and 2002, **107**]. Having participated in the INDOEX, I wish to share my views that the sources for the development of haze layer are not yet fully defined and therefore any future projections of its impacts on monsoon or agriculture are premature and must await further studies. I base my opinion on some of the results which our group at the Indian Institute of Tropical Meteorology has arrived at from analysis of the data obtained during the INDOEX and the XVI Indian Scientific Expedition to Antarctica in 1996–97. Some of these results have been published or are in press^{4–9}.

The haze layer over the northern Indian Ocean mostly consists of submicron aerosol particles with an abundance of particles in nucleation mode, i.e. of size < 20 nm (ref. 4, 5, 10, 11). The concentration of these particles is maximum near the Indian coastline and decreases southward up to the Inter Tropical Convergence Zone (ITCZ), which is normally located at about 10°S in this season. These fine

and ultra-fine particles are distributed throughout the marine boundary layer to a height of a few kilometers in vertical¹¹.

Origin of the fine and ultra-fine particles is not only from the continent but also from the free troposphere. The gas-to-particle conversion processes occurring in the outflow of large convective clouds in free troposphere form the ultra-fine particles in nucleation mode. Airborne measurements made during the INDOEX demonstrate elevated concentrations of nucleation mode particles in a layer between 8 and 12.5 km altitude¹¹. The ultra-fine particles when generated, are only 2–3 nm in diameter but grow in size by coagulation and cloud processes.

These fine particles are then transported down from free troposphere to the marine boundary layer under large-scale subsidence in the downward leg of the Hadley cell which is located at about 20–30°N in this season¹². Large concentrations of submicron particles observed over the northern Indian Ocean during the INDOEX period have been observed to be associated with strong downward motions over these latitudes^{4,5}. In the marine boundary layer these fine particles along with other continental pollutants are carried equatorward with the northeasterly winds prevailing over the northern Indian Ocean in this season. During their equatorward transport, these fine particles grow by condensation of trace gases. Therefore, the large concentrations of submicron aerosols observed in the marine boundary layer over the northern Indian Ocean comprise not only of continental aerosols but also the aerosols transported down from the free troposphere. Such equatorward transport of fine aerosols in the marine boundary layer of Hadley cell in Southern Hemisphere is also indicated in our measurements of the atmospheric electric conductivity which is a measure of the background aerosol pollution⁷.

The fine particles formed in the free troposphere are sulphate particles. So, when transported down to the marine boundary layer, they enhance the sulphate component being carried from the continent by northeasterlies in the marine boundary layer. Chemical analysis of the samples collected over the northern Indian Ocean with an aircraft and at Kaashidhoo Climate Observatory in Maldives during the

INDOEX period show that sulphate is the largest constituent (32%) of the submicron aerosol particles¹³. The whole of this sulphate component, therefore, is not due to fossil fuel combustion on the continent as implied in the UNEP report.

The northeast monsoon over South Asia is a normal annual feature of the general circulation of atmosphere and so is the formation of haze layer over this region due to transport of natural aerosols from the continent to ocean. The vastness of this layer, both in horizontal and vertical, is the result of the persistent northeasterly winds for 3–4 months in a year and the shift of the ITCZ to the Southern Hemisphere in this season. Major finding of the INDOEX has been to identify different components of anthropogenic air pollution that add to the intensification of haze layer.

One of the important observations of the INDOEX is that black carbon and fly ash constitute significant portions, up to 14% and 6%, respectively, of the aerosol particles over the Indian Ocean. These pollutants are unquestionably human produced and are caused by bio-fuel combustion and agricultural burning. The practice of this form of domestic energy consumption (for example burning of bio-fuels such as fire-wood, cow-dung and agricultural wastes) is centuries old and any change in pollution level due to their use may not be based on a one-time observation. For similar reasons, any change due to such practices may not be of immediate or catastrophic nature. Moreover, the normals of meteorological events prepared from the data obtained in ‘instrument era’ of comparatively much shorter duration, will have the embedded effects of the pollutants in this haze. Therefore, due care need be exercised in associating any abnormality of meteorological events to the anthropogenic pollutants in haze layer.

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Limited usefulness and relevance of coaching for competitive examinations

There is a proverb in Hindi which when translated into English, reads 'Even a refuse-dumping place has in time a good day'. Quite a few competent teachers are now making money from the coaching institutes/colleges/schools run for the coaching of students for the competitive examinations for the entrance to Medical/Engineering Colleges. Such coaching schools have mushroomed in the towns of Northern India and probably elsewhere too. Barring some known and established institutions which provide coaching on a planned scale, most of them are run just as class-room teaching where the number of students may vary from ten to some two hundred in a class. Some institutions provide coaching by post and also serve as examining bodies to let the candidates know where they stand. The fees for established institutes for any type of coaching may vary from Rs 30,000 to Rs 50,000. For most of the coaching schools (incidentally good!), the fees may vary from Rs 3000 to Rs 10,000 for a package teaching of a student in a group for three days in a week spread over about six months. Parents in their eagerness to see their wards become engineers/doctors somehow manage to pay the high fees, send them to these coaching schools and consider their job to be over. The wards too in a rat race not to lag behind go to these colleges/schools just to satisfy themselves that they have taken the coaching. How many parents are competent to assess whether their wards get the return for their money they spend, whether their wards are improving and preparing themselves with a competitive spirit? How

many of the candidates are competent enough to make an assessment of themselves at any time during the coaching and modify and improve their method of preparation and study?

The fact is that most of these institutes are no better than providing good classroom teaching. If students go to coaching institutes, either they are not serious in their class-rooms, or the class-room teaching itself is not up to the mark. In case the latter is true, are the parents aware of this? Why don't they collectively bring this to the notice of the school-administration? Moreover, the coaching done in these institutes is a misnomer. It is no coaching at all. (It would be known as coaching if it is one to one coaching or one teacher for two/three students.) In such a situation the fees paid by the parents to an institute or to a teacher is a largesse.

Unfortunately the parents and their wards only superficially know that these entrance examinations are competitive. They are not only competitive, but *highly* competitive. Candidates securing more than 90% marks at the Intermediate level are not sure of their admission to the Medical and Engineering Colleges through the entrance tests. The preparation for these examinations has become highly technical. It requires intelligence, hard work and extremely methodical and regular study. Answering question papers require quick reflexes of the mind and good memory. With these stringent requirements, candidates securing less than 90% marks (say between 85 to 90%) at the Intermediate level, have to

examine themselves very objectively whether they, with all resources, can rise up to the competitive level. The parents feel if they spend money, encourage their wards, and their wards work hard, it may be possible for their wards to fulfil their dreams, but the parents forget that there is a limit to the extent of improvement in the preparedness of their wards for the examination and this depends on the capacity of the wards. I feel that it is the competence (intelligence plus capacity) of the candidate rather than coaching which takes him/her through the test because coaching is a common denominator for all who take to coaching and succeed. Parents are therefore advised to get their wards objectively assessed by a couple of teachers and apply their own mind before pushing them for any coaching for the entrance tests for admission to Engineering/Medical Colleges. It is better for candidates of lesser merit to look for alternative avenues.

The two professions, Engineering and Medicine, are highly specialized and those who do not have a temperament to serve them with devotion, cannot be made to acquire the required attitude even by study and training. Our science-management in higher education must make scientific service more respectable, lucrative, challenging and self-satisfying so as to stop the drain of the cream of scientific talent to the two professions.

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