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CLIMATIC SIGNIFICANCE OF STABLE ISOTOPE CHARACTERISTICS OF AIR-CO_2 AND RAINFALL IN DELHI AREA WATER-PLANT-AIR SYSTEM

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In recent years, there is a global concern on the role of carbon dioxide in atmosphere in affecting the climate. The present models of global atmospheric circulation suggest that oceans sequester about one-third of the CO_2 released by anthropogenic activities, and biospheric productivity is the primary cause of the interannual fluctuations in the atmospheric CO_2 [1, 2]. However, most of the times, the excess of CO_2 in air is associated with the presence of anthropogenic pollutants from urbanised centres. Therefore, the studies on the pattern of local variations in the isotopic composition of air CO_2 and rainfall in urban areas are expected to provide important information on the atmospheric circulation processes which affect the climate on a regional scale. Internationally, aspects of climate change have been so far demonstrated using isotopic data mainly from temperate climates, and there is limited understanding of the factors controlling stable isotopic composition of air-CO_2 and rainfall in tropical regions. In this context, to assess the magnitude of the above mentioned effects, analysis of the data on the variations in the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ signatures of air-CO_2 in Delhi area water-plant-air system is presented here.

In Delhi area, located in the path of the Indian southwest monsoon trough movement, about eighty percent of the annual rainfall occurrs during the monsoon period (July to September). This brings a significant change in the weather and increase in the plant biomass productivity. The air-CO_2 concentration during March to September showed a wide range of 330 to 458 ppmv, with an average value of 357.8 ppmv and the $\delta^{13}C$ value of CO_2 varied from -7.8 ‰ to -11.6 ‰, with an average of -8.9 ‰. While, the pre-monsoon months (March to June) had higher CO_2 levels (mean 366 ppmv), monsoon months July and August had significantly depleted concentration (mean 345 ppmv). An inverse relationship has been observed between CO_2 concentration and $\delta^{13}C$. Depleted CO_2 concentration associated with enriched $\delta^{13}C$ value during the monsoon months clearly indicate rapid consumption of $^{12}CO_2$ by photosynthesis due to increasing biomass productivity [3]. Simple mass balance calculations suggest that before the onset of monsoon in Delhi, CO_2 contribution to the atmosphere from burning of fossil fuel ranged between 10 to 24 % in the investigated area. The $\delta^{18}O$ value of CO_2 in Delhi ranged from +38.7 ‰ to +50.9 ‰, with an average of +41.2 ‰, close to that of normal atmospheric CO_2 ($\delta^{18}O$=+41 ‰). Relative humidity of air during monsoon months being quite high (70-80 %), the depleted $\delta^{18}O$ in CO_2 during monsoon months can be possibly ascribed to equillibration of CO_2 with relatively less enriched leaf water of the vegetation [3, 4].

Analysis of the variations in the $\delta^{18}O$ and δD composition of New Delhi rainfall (IAEA Global Network Data 1961-96) showed that although, the monthly mean values range from -15.3 to +8.0 ‰ for $\delta^{18}O$ and -120 to +55.0 ‰ and agree with the world meteoric line, yet, the isotopic composition of rainfall events of less than 50 mm show deviation form the meteoric line, following different evaporation line for different summer months. Earlier studies, based on IAEA Global Network Data 1961-83 suggested that the long-term mean temperature and mean rainfall together account for about 80-95 % of the long-term average variability of ^{18}O

composition [5], with temperature alone accounting for 80 % variability. Lack of correlation between the monthly ^{18}O isotopic composition and rainfall reflect that the temporal variability in $\delta^{18}O$ depends also on the atmospheric water vapour circulation patterns, distribution and intensity of rainfall, composition of the air-mass from which the rainfall derives and the trajectory of the moist air-mass movement [5]. However, months with heavy rainfall is generally associated with depleted $\delta^{18}O$, and each monsoon months July, August and September shows different pattern of amount effect, i.e., depletion in $\delta^{18}O$ with increasing amount of rainfall, in the rainfall range of 50-350 mm. Monthly values of $\delta^{18}O$ in rainfall show maximum enrichment during the summer months May and June, and closely match with the maximum monthly temperature in the corresponding year, and is associated with higher air-CO_2 level in some of the years. The data suggest that as compared to the monthly isotopic composition of rainfall in the normal monsoon years, relatively enriched monthly $\delta^{18}O$ in rainfall in other years is generally associated with El Nino years and rainfall deficient years. Although, it is difficult to ascertain whether El Nino affects India, as the Indian monsoon is a very complex phenomenon, yet, studies reported earlier found that El Nino years are associated with weak Indian summer monsoon [2]. Since, average monthly atmospheric circulation features in normal monsoon years differ considerably from that in deficient monsoon years, further systematic monitoring and modelling of seasonal variations in isotopic composition of rainfall and air-CO_2 can provide useful information on the environmental changes and distribution of water in the atmosphere, in relation to the atmospheric circulation patterns, as influenced by green house gases.

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