

onments. The sources of these precursors are vehicular exhaust, industrial emissions, change in land use patterns and a large number of biological processes. In this respect, in the urban environment vehicular exhaust (which consists of NO_x and VOC) is the main source of tropospheric ozone formation. Therefore to reduce the tropospheric ozone concentration in the urban environment, it is necessary to cut down its precursors concentrations, namely the vehicular exhaust.

The maximum tropospheric ozone will be produced at the ratio $\text{VOC}/\text{NO}_x \sim 6$; this condition is described as maximum incremental reactivity, here reactivity meaning the ozone-forming potential. Therefore maximum or peak tropospheric ozone formation is a function of VOC/NO_x ratios and not any individual precursor concentration. It is important to reduce the concentrations of both VOC and NO_x to curtail the ozone concentrations. Because of this complex and nonlinear nature of the chemical system, the environment is classified as NO_x -limited, if VOC/NO_x ratio is greater than 6 and it is VOC-limited, if VOC/NO_x ratio is less than 6, depending upon the VOC and NO_x concentrations.

Atmospheric chemistry of tropospheric ozone formation in the NO_x -limited environment is linear and simple. As long as the chemical system is NO_x -limited, tropospheric ozone formation is a function of NO_x concentration. Therefore it is easy to reduce the ozone concentrations in such an environment by reducing NO_x

concentrations. This type of environment is found in the free troposphere (2 km to tropopause), (about 16 km altitude from the earth surface in tropics) level, remote and oceanic regions where NO_x concentration is low. If the chemical system becomes VOC-limited, then tropospheric ozone-forming mechanisms are more complex and nonlinear. This type of urban environment is characterized as highly polluted and is known as NO_x -saturated. Such high NO_x concentrations are experienced in the atmospheric boundary layer (from the surface of the earth to 2 km height) of the urban atmosphere. In such a situation the abatement policies of ozone become more complex, less effective and less economically viable. For example, after reducing 50% of VOC and NO_x , ozone reduces by 12% only. This indicates that ozone reduction is a highly nonlinear function of its precursor concentrations. Furthermore, because of nonlinearity in ozone-producing mechanisms in the NO_x -saturated environment, if the NO_x concentration is reduced, then ozone concentration will increase instead of decreasing. The VOC reduction is required first in such a type of environment and then NO_x . It is not an easy task to reduce VOC, because of a very large number of anthropogenic as well as natural sources. Because of this, cities like Los Angeles, London and Tokyo are experiencing ozone concentrations more than the prescribed permissible limit of 80 ppbv (parts per billion by volume) set by WHO. In fact, after spending billions

of dollars, these countries have failed to attain ozone concentration less than 80 ppbv in their environment because of the nonlinear and complex nature of chemical systems in the VOC-limited environment. At present, Asian and other developing countries are experiencing NO_x -limited environment and hence ozone abatement is easier in these regions than in developed countries. The concern is that major cities like New Delhi, Mumbai, Calcutta, Chennai and Hong Kong are approaching the VOC-limited environment. Therefore, at this stage, there is an urgent need to reduce the NO_x concentration by reducing the vehicular exhaust through stern legal action. Ozone abatement is easier as long as there is a NO_x -limited environment, but once the urban environment becomes VOC-limited, it is very difficult to reduce ozone concentrations.

The present research shows that ozone concentration is increasing at a rate of about 2% per year in the Asian region which is higher than that in developed countries (about 1 to 1.5%) because of ineffective pollution control policies. Effective pollution control policies, enforcement, effective combustion technologies and public awareness about the environment are needed to be undertaken at the earliest.

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NEWS

Diversification of agriculture for human nutrition*

Green revolution followed by white, yellow and blue revolutions has gone a long way in providing food security at the national level despite the marked increase in population. This however has

not ensured household nutrition security for a variety of reasons. The complex relationship between diversification of agriculture (food grains, horticulture, livestock) and its impact on human nutrition, demand for resources and socio-economic determinants of diversification was discussed at a symposium on 'Diversification of Agriculture for Human Nutrition'. Sobhanadreshwara Rao, Minister for Agriculture and Horticulture, Government of Andhra Pradesh, inaugurated the

conference and said that the new agricultural policy being formulated aimed at increasing the yields of food crops by making the optimum use of the available technologies. Mahtab Bamji, convener of the symposium, said that the true index of development of a country is the health and nutrition status of its people and not just industrial or economic growth. This requires close interaction between agriculture and nutrition scientists, planners and policy makers and the farmers.

*Report of a symposium on 'Diversification of Agriculture for Human Nutrition' organized by the National Academy of Agricultural Sciences (NAAS), at the National Institute of Nutrition, Hyderabad during 16-17 December 1999.

Kamala Krishnaswamy (National Institute of Nutrition) posed the problem of malnutrition in the country. The surveys conducted by the National Nutrition Monitoring Bureau show that the diet of urban and rural poor is deficient in several nutrients, notably vitamins and minerals. Diversification to nutrient-rich millets, fruits, vegetables and livestock products can help to bridge the gap in nutrient intakes provided these foods are accessible to the poor. According to M. V. Rao, while the production of rice and wheat have shown remarkable increase both in terms of area and productivity per unit area, production of millets and legumes (pulses) has languished. J. S. Kanwar pointed out the magnitude of problem due to diminishing soil fertility and water availability. The need for further research to improve the productivity of coarse food grains and pulses which can be grown in rain-fed areas was stressed by N. G. P. Rao.

Today, India ranks first in the production of milk and second in the production of fruits. Even so, the production fails to meet the present demand for fruits, vegetables and livestock products due to low productivity and post-harvest losses. The intake of these protective foods by the poor has shown none or only marginal increase.

G. L. Kaul recommended uprooting or rejuvenation of unproductive plantations, access to high quality planting material and technologies, chains of packaging and storage houses, and zero energy cooling chambers at farmsteads to improve productivity and reduce perishability of horticulture produce. Apart from providing the precious micronutrients, fruits and vegetables can also provide healthy bioactive phytochemicals. The need for enhanced production of fruits and vegetables like green leafy vegetables, which have high micronutrient content was stressed by K. L. Chadha.

K. Pradhan pointed out that while the annual growth of food grains has been 2-3%, that of livestock is 10-15%. Despite this the availability of these products to meet the requirements is far below the ICMR recommendations. Due to unequal purchasing power, the increase is not evenly reflected in the diet of all segments of the population.

To produce livestock products other than fish, 2-5 times the quantity of food

grains is required. This has created pressure on food grains for livestock feed in the world. However, in India livestock are largely raised on farm waste, oil cakes and food grain unfit for human consumption. The small quantity (less than 5%) diverted from food grains used for direct human consumption, is converted to nutritionally value-added food in terms of livestock products and would be expected to have positive impact on nutrition. Research is needed to improve the feed efficiency and genetic quality of the livestock to make the plant-livestock-human chain more efficient. The fear of diverting land from food grains to horticulture or livestock production seems unfounded, since such diversification has occurred in rain-fed, hilly and coastal regions, and has benefited the land-less and marginal farmers.

According to S. C. Mohapatra, demand for eggs and their production has tended to plateau in recent years because of changing food preferences among the urban people, and relative inaccessibility to rural markets. Poultry farming has been mostly a peri-urban activity. There is good scope for backyard poultry using indigenously developed breeds to capture the rural market. The demand for poultry meat is however increasing and is likely to go up further. There is scope for increasing the production of other birds like ducks, turkey, quail, etc.

K. Gopakumar said that fish has been an important export commodity. Overproduction of prawns in aquaculture using unscientific methods has created environmental problems. However, scientifically performed, high-tech fish farming is environmentally sound and ensures stable supply. Scientific fishing and the fish industry require large investments but have potential for good returns. Care should be taken to see that the livelihood of small fishermen is not threatened by high-tech deep-sea fishing. Nutritionally, fish is a good food containing high quality proteins, and long-chain, omega 3 fatty acids and low cholesterol.

The scope of genetically modified foods was discussed by R. P. Sharma. Nutritionally-enriched foods like rice are already available and they can help nutrition security if accessible to the poor. India needs to strengthen research in this area and put in place proper mechanisms for monitoring and ensuring the safety of genetically modified foods.

Food processing can play an important role in value addition and improving the shelf-life of farm produce. India's share in processed foods is negligible. According to V. Prakash, even small-scale food industries can become viable with proper planning and linkages.

Though household food security is an important determinant of nutrition status, interstate comparisons within India show that other factors, mainly female literacy contribute significantly to better nutrition status. An analysis of the NSSO data, done by Praduman Kumar, suggests that farm size, improved agricultural technology, irrigation (even less than 19%), presence of farm animals and literacy have positive impact on nutrition as judged by calorie intake. Diversification within food crops and between food crops and livestock helps nutrition security, particularly for small and marginal farmers. Similar trends were seen in a micro study in Andhra Pradesh discussed by P. Geervani. However, Geervani pointed out that diversification to non-food crops must ensure local food and nutrition security and community education to ensure that additional income is used for food.

An interesting paradox between poverty line and calorie adequacy was brought out by Padamsingh. While in 1973-1974 there was agreement between the two parameters, in subsequent years the percentage below the calorie norm was higher than the percentage below the poverty line.

States in which crop diversification has occurred have shown higher growth rate and net domestic product according to the agricultural-economist Ramesh Chand. While during the first 15 years after the green revolution, irrigation helped diversification, in subsequent years excess irrigation resulted in rigidity. Institutional credit availability helped diversification. Thus it would appear that availability of some but not excessive irrigation facility and power supply, and institutional credit would help diversification. Kirti Singh pointed to the need of having special schemes to benefit the most socially and economically backward sections.

In the concluding plenary discussion, R. S. Paroda highlighted some areas of concern such as large population of unproductive farm animals, mismatch between demand and supply of diversi-

fied products, (e.g. soybean), pressures on land and water resources, and preservation of genetic resources. He stressed the need for increased productivity through science and technology inputs, optimum resource management, education and training of farmers to make them aware of new technologies, regional planning for agriculture, and develop-

ment of some of the remote areas like the NE region.

In conclusion, it was felt that agricultural diversification within food grains (millets, legumes beside cereals) and between food grains, and horticulture (fruits and vegetables) and livestock products is essential for both national and household food and nutrition security. If

planned properly it can benefit the poor both nutritionally and economically.

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An overview of heavy metals: Impact and remediation*

Heavy metals are considered as major environmental pollutants and are regarded to be cytotoxic, mutagenic and carcinogenic. Prominent sources contributing to contamination of soil are: geogenic, mining and smelting, disposal of municipal industrial wastes, use of fertilizers, pesticides and automobiles. Natural contamination of soil and groundwater with arsenic, selenium and fluoride in many parts of the world, particularly in the Australasia-Pacific region, is a cause of great concern to human health. With this in mind, a conference on contaminants in soil environment in this region was held. The key points that emerged during scientific deliberations are highlighted here. R. S. Paroda (Department of Agricultural Research and Education, and ICAR) in his inaugural address stressed that in the realm of sustainable agricultural development soil health is very important to achieve future food security targets. Saon Banerjee suggested that environmental monitoring of radio nuclide contamination is highly essential as more and more nuclear power plants are expected to be installed for generation of power and in the industry in the future. C. Mahanta studied the distribution and fractionation of Cu, Pb, Zn, Mn, Fe, Ni and Cr along the 700-km stretch of the Brahmaputra river falling within India. Shashi Mathur developed a simple macroscopic root uptake model that simulates both the water and cadmium uptake by plant roots contaminated with sewage sludge. Jeevan Rao concluded that indis-

criminate and over use of garbage as manure in Hyderabad for a long time resulted in pollution of natural resources like soil and water and plant growth was also affected due to the build-up of soluble salts, sodium and heavy metals. G. R. M. Reddy reported higher contents of heavy metals, viz. Pb, Cd, Ni, Cr and Co in sewage-irrigated soils of Hyderabad. S. K. Singh predicted the danger of heavy metals build-up in Sikandarabad soils irrigated with mixed industrial effluents. T. Srinath reported that heavy metal contamination (mg/kg) in the sludge of tannery effluent treatment plant was of the order of Cr (37,797) > Fe (2574) > Ni (1287) > Mn (110.6) > Cu (90.4) > Pb (79.8) > Zn (15.5) > Cd (4.6). He also cautioned against the use of tannery sludges as manure in agriculture. O. P. Bansal reported that concentrations of Cr and Cd in groundwater of Aligarh district, Uttar Pradesh were at the threshold level and further accumulation may cause toxicity. V. Bhardwaj reported that the exhaust from the vehicular transport has contaminated the road-side vegetation and soils of Nainital Tarai area with lead. The problem of lead contamination was aggravated by traffic intensity, wind direction and roughness of the leaf surface. K. M. Nair reported that Vrishabhavati river water, the primary source of land pollution in Bangalore, contained Cu 138, Zn 261, Pb 100, Ni 54 and Cr 34 µg/l and plants grown in such soils absorb enough metal to render their edible tissues unfit for animal/human consumption. R. N. Sharma developed a complete early warning system for the detection of copper, mercury, cadmium, lead, chromium, cobalt and aluminium by using biomonitors such as *Poecilia reticulata*

(guppy fish), *Ades aegypti* (mosquito), *Musca domestica* (housefly), *Chironomus* sp. and *Mesocyclops leuckrati*. K. Ramasamy reported that tanneries in Tamil Nadu are responsible for elevated levels of Cr, Na and other salts in well waters of Vellore district. Ravi Naidu (Australia) reported higher levels of Cr (800–40,000 mg/kg) in tannery sludges in South India. S. Sakthivel and S. Mahimairaja reported that irrigation with treated tannery effluents had a significant impact on tree growth and marketable flower yield of flower crops. K. Shanthi reported the concentrations of Cu, Zn, Ni, Pb, Cd, Cr, Fe and Mn in sediments of six wet lands of Coimbatore. Mahimairaja assessed the status and distribution of Cr in tannery waste contaminated soils of Vellore district, Tamil Nadu, where > 70% of the tannery industries are located. Total chromium and Cr (VI) in these soils ranged from 154.5 to 568 and from 48 to 467 µg/l, respectively. Narwal cautioned that continuous use of sewage crops may affect the animal/human health adversely by causing accumulation of heavy metals in the soil. M. Bhaskar reported that one-time addition of flyash did not cause heavy metal toxicity that would affect soil health and crop production. U. N. Joshi reported that activity of enzymes related to carbon and nitrogen metabolism increased in 1 ppm Cr(VI) treated plants and then decreased at higher concentrations of Cr(VI), resulting in poor and stunted plant growth at higher Cr(VI) concentrations. In alluvial soils of Punjab the total content of heavy metals (Zn, Cu, Mn and Mo) was by and large within and those of Co and Cr were more than that of the minimum permissible limit (P. N. Takkar). K. S. Dhillon

*Report on the 2nd International Conference on Contaminants in Soil Environment in the Australasia-Pacific Region, held in New Delhi during 12–17 December 1999.