Chapter 14
Tropospheric Ozone Pollution, Agriculture, and Food Security

Abhijit Sarkar
University of Gour Banga, India

Sambit Datta
University of Calcutta, India

Pooja Singh
Banaras Hindu University, India

ABSTRACT

Increasing population and unsustainable exploitation of nature and natural resources have made "food security" a burning issue in the 21st century. During the last 50 years, the global population has more than doubled, from 3 billion in 1959 to 6.7 billion in 2009. It is predicted that the human population will reach 8.7 - 11.3 billion by the year 2050. Growth in the global livestock industry has also been continuous over the last two decades. An almost 82% increase in future livestock is expected in developing countries within 2020, due to an expanding requirement for food of animal origin. Hence, the future demand of this increased human and livestock population will put enormous pressure on the agricultural sectors for providing sufficient food and fodder as well as income, employment and other essential ecosystem services. Therefore, a normal approach for any nation / region is to strengthen its agricultural production for meeting future demands and provide food security. Tropospheric ozone (O_3), a secondary air pollutant and a major greenhouse gas, has already been recognized as a major component of predicted global climate change. Numerous studies have confirmed the negative impact of O_3 on agricultural productivity throughout the world. The present chapter reviews the available literature, and catalogue the impact of this important gas pollutant on modern day agricultural production worldwide.

INTRODUCTION

Ozone (O_3) whether in stratosphere or troposphere has been a major talking issue for scientists, policy makers, and even the common man since last couple of decades. In stratosphere this tri-oxygen provides a crucial barrier against incoming solar ultraviolet radiation and protects life on earth; so depletion of O_3

DOI: 10.4018/978-1-5225-1683-5.ch014

layer in stratosphere is a problem. However, in troposphere it is a gaseous pollutant with negative impact on human and animal respiration as well as causing severe damage to both natural and cultivated plant populations (Cho et al, 2011); so, rising of O_3 level in troposphere is again a major crisis. Now, which one is more serious problem – might be a million-dollar question; but, this present section mainly focuses to review the available scientific literatures which specifically deal with the O_3 formed in the troposphere and its further consequences mainly on plant's health and productivity. Although, some O_3 is believed to be transferred from the stratosphere to the troposphere too; but the amount is debatable (Jaffe, 2003).

THE ATMOSPHERIC O_3: GOOD UP HIGH, BAD NEARBY

Ozone is generally present as a trace gas in our atmosphere, averaging about three molecules for every 10 million air molecules. In spite of this very small quantity, O_3 plays a vital function in controlling the atmospheric chemistry. This trace gas is mainly found in two different regions of Earth's atmosphere. The major amount of the total atmospheric O_3 (approximately 90%) exist in a layer that begins between 10 and 17 kilometers above the Earth's surface and extends up to about 50 kilometers. This region of the atmosphere is called 'stratosphere' and the stratospheric O_3 is commonly known as the 'ozone layer'. The remaining O_3 is present in the lower region of the atmosphere, which is commonly called 'troposphere'. Though the O_3 molecules at upper atmosphere, i.e. stratosphere, and lower atmosphere, i.e. troposphere, are chemically identical but they perform very different roles in atmosphere as well as show very different effects on the living world too. The stratospheric O_3 (sometimes referred as 'good ozone') plays a valuable role for living world by absorbing most of the biologically damaging ultraviolet sunlight (UV-B), allowing only a small amount to reach the Earth's surface. The absorption of ultraviolet radiation by O_3 creates a source of heat, which actually forms the stratosphere itself (a region in which the temperature rises as one goes to higher altitudes). Ozone thus plays a key role in the temperature structure of the Earth's atmosphere. Without the filtering action of the O_3 layer, more of the Sun's UV – B radiation would penetrate the atmosphere and would reach the Earth's surface. Many experimental studies of plants and animals and clinical studies of humans have shown the harmful effects of excessive exposure to UV-B radiation. However, in the troposphere, O_3 acts as a harmful gaseous pollutant which itself affects the health and productivity of all the living forms.

TROPOSPHERIC OZONE CYCLE: FORMATION, DEPOSITION AND TRANSPORT OF OZONE IN TROPOSPHERE

Being a secondary pollutant in nature tropospheric O_3 is generally formed by the photo-chemical reactions between oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) in the presence of bright sunlight. Even, O_3 also formed from the methane emitted from swamps and wetlands and some other primary pollutants through similar reactions; and through long range transport O_3 travels huge distances and spreads over larger areas (Kondratyev & Varotsos, 2001; Varotsos et al., 2004). VOCs emission has not contributed significantly to increasing tropospheric O_3 concentrations (Fiore et al., 2002).

The chemical reactions involved in tropospheric O_3 formation are a series of complex cycles in which carbon-monoxide and VOCs are oxidized to water vapor and carbon dioxide. The oxidation occurs in