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Review

Methane production, oxidation and mitigation: A mechanistic understanding and comprehensive evaluation of influencing factors

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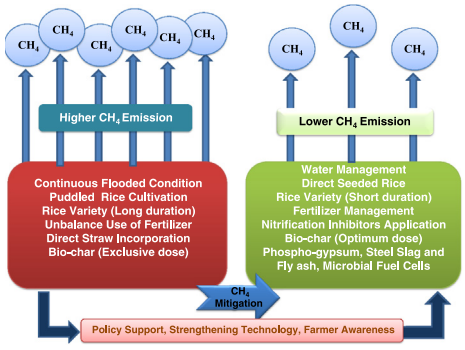
HIGHLIGHTS

- Water management (controlled irrigation and midseason drying) is the best CH_4 mitigating option in irrigated rice field.
- Ammonium based fertilizer having up to 60% CH_4 mitigation potential.
- Biofertilizer (Azolla and Cynobacteria) are best for sustainable rice cultivation.
- Microbial fuel cells are the least explore mitigation option in flooded rice field.

GRAPHICAL ABSTRACT



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ABSTRACT

Methane is one of the critical greenhouse gases, which absorb long wavelength radiation, affects the chemistry of atmosphere and contributes to global climate change. Rice ecosystem is one of the major anthropogenic sources of methane. The anaerobic waterlogged soil in rice field provides an ideal environment to methanogens for methanogenesis. However, the rate of methanogenesis differs according to rice cultivation regions due to a number of biological, environmental and physical factors like carbon sources, pH, Eh, temperature etc. The interplay between the different conditions and factors may also convert the rice fields into sink from source temporarily. Mechanistic understanding and comprehensive evaluation of these variations and responsible factors are urgently required for designing new mitigation options and evaluation of reported option in different climatic conditions. The objective of this review paper is to develop conclusive understanding on the methane production, oxidation, and emission and methane measurement techniques from rice field along with its mitigation/abatement mechanism to explore the possible reduction techniques from rice ecosystem.

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Contents

1. Introduction

Methane (CH_4) is a colorless, odorless greenhouse gas (GHG) which burns with a blue flame and was discovered by Allessandro Volta in 1778. CH_4 also has some unique physical properties like boiling point of −162.6 °C, density of 0.4240, C—H and H—H bond length of 1.1068 and 1.8118 **Å** respectively which make it different from other alkanes (Crabtree, 1995). Due to H—C—H, CH_4 has tetrahedral geometry and its bond angle is equal to 109.5° (Fig. 1a). Geophysical properties of CH_4 such as its atmospheric residence time of 12.4 years and instantaneous forcing of 1.37×10^5 W/m^2/ppb make it an important greenhouse gases (IPCC, 2014) contributing 20% to anthropogenic greenhouse effect (Cheng-Fang et al., 2012).

Greenhouse effect (GHE) in the atmosphere plays a vital role in existence of life on earth as it prominently influences the temperature regime of many ecosystems including rice (*Oryza sativa* L.) ecosystem. Masters and Ela (2010) reported that the mean temperature of earth would be -19 °C without GHE, which would be limiting factor for life existences on earth. Most of the vital activities such as physiochemical reaction in plants are controlled by the temperature, which vary with ecosystems. The global earth surface temperature has increased by 0.88 °C due to enhanced GHE in the late nineteenth century (Cheng-Fang et al., 2012). IPCC (2013) projected 1.5 to 4.5 °C rise in global mean annual temperature by the end of twenty-first century.CH_4 is second most potent greenhouse gas on the basis of global warming potential (a quantification of the averaged relative radiative forcing impacts of a particular GHG as set 1 for CO_2). In the duration of last two decades different scientific reports reveal different global warming potential (GWP) of CH_4 which range from 15 to 34 (Table 1) as compared to CO_2. Atmospheric concentration of CH_4 has increased from a pre-industrial 715 to 1774 ppb (Khosa et al., 2011).

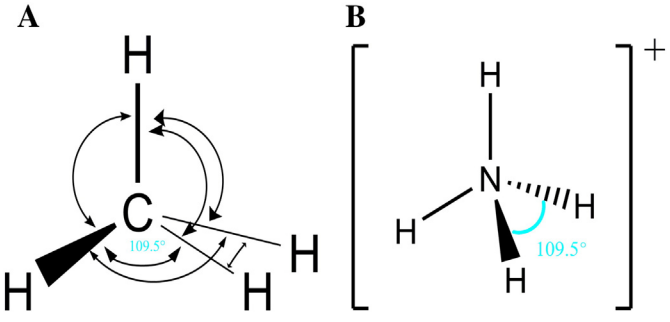

Fig. 1. a. Methane tetrahedral geometry shape. b. Ammonium ion tetrahedral geometry shape.