ORIGINAL RESEARCH ARTICLE

NATURAL GAS FLARING AND ADAPTIVE STRATEGIES OF PLANT AND INSECT

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ABSTRACT:

Growing anthropogenic tendency is supposed to responsible for the fluctuation of environmental components in recent days. Flaring of natural gas is a common practice of crude oil exploration units. Activities of flaring alter environmental composition by the addition of a huge amount of carbon dioxide and a number of hydrocarbons in to the surrounding atmosphere. Adverse effect of such activities was seen in living organisms of adjoining areas. Carbon dioxide is a prime gaseous product of such activities, interact both directly and indirectly upon the adjoining biota. Being a diverse group of organisms as well as their sensitivity to surrounding environmental condition, insect can respond quickly to such activities. Therefore, adaptive response of insect and their linked species can be applicable to document environmental perturbation caused by natural gas flaring in future.

KEYWORDS: Natural gas, Flaring, Adaption, Plant, Insect.

INTRODUCTION:

Environmental oscillation resultant increase atmospheric carbon dioxide concentration is supposed to be a major cause of global warming. Global warming is an important issue of discussion among scientific community for sustaining biodiversity and managing food security of the biosphere [1], [2]. Drastic changes in concentration of carbon dioxide has been observed at Mauna Loa in Hawaii since 1958 and the concentration is likely to be raised up to 800µmol (CO_2) by 2100 according to some climate model forecast [3]. Petro-chemical companies are substantially responsible for this phenomenon (releasing 340 million tons of CO_2) by flaring natural gas into the atmosphere every year all over the world during crude oil exploration practices [4]. Gas flaring of natural gas during the crude oil production of oil companies is a common process and about 115 billion cubic meters of natural gas is flared or vented into the atmosphere in each year all over the world. Being a high temperature oxidation process, gas flaring combustible components, including natural gas as well as various hydrocarbons are burnt to protect the pipes or vessels from over pressure [5].Quantity of flared gas is dependable to the extent of gaseous hydrocarbons generated during the oil exploration.Petroleum sectors are supposed to be a major source of economy. However, emitting toxic and injurious gas to the atmosphere, these industries imbalance ecosystem process [6]. Although, flaring impact was supposed to focus primarily at local level, but global impact can be predicted in some extent with the addition of carbon dioxide concentration in the atmosphere during this process. The free disposal of gas through flaring generates greenhouse effect, temperature escalation, health hazards problems upon local community as well as poor agricultural production and acid rain effect etc. [6],[7], [8],[9],[10],[11],[12],[13],[14]. Gas flaring emits about 250 numbers of toxin (most of them are carcinogenic) with a numbers of greenhouse gases and may contribute to diverse numbers of environmental effect at local as well as global level [6], [15]. Recently, in a study conducted in Niger Delta revealed extension of these pollutants to the adjoining areas of gas flare [16]. Pollutants released during this process damages the quality of air, soil and water and has adverse effects on adjoining biota [17].

However, fluctuations of atmospheric carbon dioxide, temperature and changes patterns of precipitation have severe impact upon soil organic carbon. Carbon dioxide is the prime gaseous product of gas flaring. It is a greenhouse gas and has capability to absorb UV rays thus become a potential contributor of global warming. Apart from this, sulphur dioxides, carbon dioxides and oxides of nitrogen are a few greenhouse gases added to the air from such emission. Sulphuric acid and nitric acid also form after interaction of sulphur dioxide and nitrous oxide with atmospheric moisture, respectively. However, during the process a number of other pollutants contaminate air, soil and water at local and regional level [17]. Contamination of these pollutants is not only harmful to human, but also threatening for the existence of important biological resources. Large numbers of floral as well as faunal wealth of our ecosystem may be affected in this process [18]. Greenhouse gases, mostly CO_2 interacts within and between biotic and abiotic components of the ecosystem [19] as well as play a significant role in different biome including plant species and insect herbivores performance [20],[21]. Rising of CO_2 is a cause of concern for global climate change as expected to induce physiological changes in plants, including reduction in foliar nitrogen, which are likely to affect herbivore densities [22],[23]. Scientists believe that increasing level of atmospheric CO_2 can have significant effect on plant suitability for insects due to deficient nitrogen concentration. Elevation of carbon dioxide is responsible for altering plant-insect herbivore interaction by changing leaf chemistry and nutritional quality of plant i.e. detrimental for plant defense chemicals and effect on leaf feeder performance [24],[25].

North East India is a hotspot of biodiversity. In this regard, Assam, a state of unique biodiversity as well as rich natural resources, there is an urgent need of study of gas flaring and its impact on adjoining biota. With a huge numbers of oil and natural gas reservoir it is one of the largest contributors of country's economy. Therefore a huge number of oil exploration units are come up in each year in the region and such operation creates havoc for biological system living in the proximity. Exploration of crude oil in North east India was started during colonial period at Digboi of Upper Assam region. With the increasing trend of modern civilisation, a huge numbers of crude oil exploration units have come up each year in the region. These units are mostly established in proximity to tea garden, agricultural fields and human habitation areas. Activities of these crude oil exploration units released a huge amount of carbon dioxide in the adjoining area and previous study reported higher level of carbon dioxide in those areas [18]. Apart from this pollutants released during crude oil exploration process contaminate air, soil and water at local and regional level [17]. Contamination of these pollutants is not only harmful to human, but also threatening for the existence of important biological resources. A numbers of studies were conducted in the adjoining areas of group gathering stations at Sivasagar District of Assam documented declination of butterfly and host plant diversity. Apart from this, low silk quality of some economic insects including Muga silk worm was reported in oil field pollution areas of upper Assam [18].

Gas flaring scenario in India:

Flaring of natural gas during crude oil production is a common process of oil exploration unit. About 150 billion cubic meters of natural gas flared or vented into the atmosphere annually all over the world during this process [26].Among the most gas flaring countries, Libya flares about 21% of its natural gases followed by Saudi Arabia (20%), Canada (8%) and Algeria [27]. In India, flaring of natural gas has been starting since 1957 while first drilling operation of oil was started during 1889 at Digboi of upper Assam. India contributes about 14 million tonnes of CO_2 by the gas flaring process while Assam contributes about 3.14 million tonnes [28]. Being a state of rich natural resources, Assam has a long history of oil exploration with Digboi oil refinery. After exploration of oil in Digboi, a huge number of companies carried out the process and explored this liquid gold in the region. During pre-independent, oil and natural gas commission carried out the process. After few years, Assam Oil Company Limited played major role by discovering a large number of new oil exploration units in upper Assam area. During last few years, a huge number of oil exploration units have been come up, resulting more oil and natural gas production in the region. Today (2015-16), crude oil production in Assam raises to 36.950 Million Metric Tonnes (MMT) (Ministry of Petroleum and Natural Gas 2015-16 Report). Gross production of natural gas in India (including offshore and onshore) accounted to 33,657.44 MMSCM during 2014-15, where about 865.11 MMSCM was flared. During 2015-16, the natural gas production was 32,249.21 MMSCM, while flared quantity was 1006.35 MMSCM i.e. more than the previous one. India flared about 3.12% of total gas production during 2015-16 which was higher than previous years (Ministry of Petroleum and Natural Gas 2015-16 Report). Assam produced about 32.249 BCM of natural gas during 2015-16 and 33.657 BCM in 2014-15. Assam flared about 178.29 MMSCM of natural gas which is 6.07% of total natural gas produced in the region (Ministry of Petroleum and Natural Gas 2015-16 Report).

Effect of gas flaring:

Natural gas is mostly a composition of light hydrocarbon. Thus, flaring of natural gas added huge amount of carbon dioxide as a main gaseous product accompanied by other toxic components in our atmosphere. Gas flaring associated with crude oil exploration is a part of safety management process applied by various gas agencies all over the world. However, a number of factors including flare design, operating conditions, chemical composition of associate gas have great influence upon gas flaring and venting. However, in reality achievement of complete combustion is rare [29]. Combustion performance as well as efficiency of combustion of gas flaring are dependable to energy density of the flare gas stream, flare design, flare gas composition and condition of the abiotic environmental parameters including ambient temperature, wind speed and direction, stoichiometric mixing ratios, stack exit velocity and heating value [29],[30],[31]. Carbon dioxide is released during full combustion process of gas flaring while incomplete combustion lead to release of carbon monoxide. Addition of huge amount of greenhouse gases along with other noxious gases and hydrocarbons to the atmosphere during this process [32] has crucial effect on global warming as well as climate change. Previous studies conducted in some flares of Nigeria documented effect of acid rain (6). Under high humid condition, burnt off combustible vapour may in turn form acid rain [33],[34] and thus degrading the aerial as well as aquatic environmental quality in the adjoining areas. More acidic water and corrosion rate of steel roof was recorded at close to the flare in some gas flaring sites of Nigeria (6). Thermal effect of gas flaring cannot be ignored with variation in temperature with respect to distance from flare in different seasons. Carbon dioxide released from flares makes environment warmer by absorbing infrared part of the solar radiation. Elevated temperature has harmful effect on human health, vegetation cover and soil quality via physical, biological and chemical process [14].In some studies conducted in the adjoining areas of gas flaring sites was reported microclimatic variation as well as disruption of physio-chemical properties of air, soil and water in the entire gas flaring sites in Niger Delta [13], [35], [36]&[14]. Many researchers revealed flaring of natural gas as a major cause of low agricultural productivity as well as alter socio economical pattern of local community in some gas flaring areas of Niger Delta[37],[38],[39]. In this context, reduction in productivity of some crops in the adjoining areas of flaring sites was reported by a numbers of scientific studies [40], [41].

Among organisms, insect attains more attention due to their natural interaction with diverse groups of plant communities as well as they are also sensitive to current escalation of ecosystem. Insect are easy to handle, have ecological faithfulness and possess fragility to small changes of atmosphere and thus make them more suitable as bio indicator of environment [42]. In this respect, butterflies [43],[44] and honey bee were applied as an ecosystem, biodiversity and pollution indicator during past years [45]. A number of authors have investigated the effects of plant quality upon herbivorous insects too [46]. In this regard, elemental stoichiometry adds new dimension to nutritional ecology of this sensitive organism [47]. Nutritional ecology primarily addresses feeding performance of insects e.g. food consumption, utilization and thus play crucial role in managing insects biology. Nitrogen is strategic for insect growth and development and plays crucial role in nutritional biology [48]. In spite of enormous variation in plant, insects maintain their requirements by means of flexible feeding behaviour as well as nutrient utilization [49]. However, by higher digestive efficiency phytophagous insects performs some compensatory responses to maintain their growth under limited nitrogen level in hosts. Elevated carbon dioxide has both direct as well as indirect influences upon invertebrates [50]. In such condition sometimes higher carbon and nitrogen ratios of host plant may stimulate greater feeding performance under. Prominent effects of climate change including stomata closure, higher leaf surface temperatures etc. finally has impact over insect herbivore performance [51]. Limited experimental evidence exists on direct effects of CO_2 upon insect [52], while temperature plays crucial role [53],[54],[55], [56].

Elevation of carbon dioxide likely to effect on insect populations directly and indirectly through changing plant chemistry. Simultaneous effect of elevated CO_2 and increased temperature has been accelerated the growth and development rate in insect [57], [58] however interactive effect behind this phenomena is still unknown. Higher carbon accumulation enhanced total dry weight of the plant likely to impact on insect growth [59], [60]. Previous study revealed higher photosynthetic rate of plant growing under the elevated CO_2 condition which drive faster growth as well as accumulate more biomass at maturity of the plant[61],[62], [63]. Similar trend of results also observed in someC_3 plants under elevated CO_2 condition [64]. However, a few contradictory results were recorded in terms of increasing number of flowers and buds [65], whereas others reported decreasing trend of flowers and buds when exposed to elevated CO_2 level [64]. Dynamics changes of carbon and nitrogen ratio may be the outcome of elevated CO_2 and temperature interactive effect [66]. Nitrogen is the key element of growth and development of insect and limitation of nitrogen may alter growth and development of plant under elevated CO_2 condition [67], [68], [69]. Dilution effect of nitrogen under such condition may reduce nitrogen contents in plant according to the demand as well as uptake [70]. Changes in plant carbon, nitrogen as well as levels of defensive compounds including phenolics have [71] considerable impact on insect biology. Elevated level of greenhouse gases may upsurge the reproductive capabilities and altered distribution range of some insects; thus it could change the abundance of some pest species as well as a number of vectors of disease [71].

Elevated CO_2 accompanied by higher temperature accelerate photosynthesis process consequently promote faster and better development of plant [57], [58], [72] however their interactive effect is still a mysterious fact. Effect of elevated carbon dioxide is associated with temperature as well as weather pattern and has major influences upon plant biology [73] and several thousand scientific articles have been generated in this regards. Quality of plant as well as feeding performance of insect herbivore under higher carbon dioxide concentration performs no definite patterns of action. Existing literature based on plant insect performance under such condition outlined variable effects in terms of species specific responses. Reduction of nitrogen content in plant will limit growth, survival and food nutritional rate in insects under such condition. First study based on gas flaring was documented reduced chlorophyll content in *Eupatorium odoratum* living towards the flare point [74]. In Niger Delta, flaring of natural gas was supposed to be the prime cause behind poor agriculture production [75]. In this respect, degradation of plant proteins and carbohydrates observed more on the crops that grown close to the flare. However, thermal fluctuation at gas flaring areas may also responsible for deteriorating microbes from organic matter decomposition and nitrogen formation [76]. Apart from this, properties of soil as well as nutrient cycles were found to be affected [77]. Perhaps, gas flaring influence on degradation of air, soil and water quality [78],[79] in the adjoining areas of gas flaring sites and thus reduced the productivity and yield of some farm crops. Harmful effects of gas flaring was documented over 10 hectares vegetation areas in Niger Delta [6], [80],[81]. Acid rain is a dangerous outcome of gas flaring produced within the flaring area [82],[83],[84]. However, no reasonable studies have been done so far to authenticate the impact of gas flaring upon physical, chemical, biological, atmospheric, soil and social environment [85].

Response of plant and insect under elevated carbon dioxide condition:

In ecosystem functioning, diversity of plant as well as insect play significant role. However, changes in atmospheric composition due to various anthropogenic activities may lead to influence in the interaction of both the organisms. Among the atmospheric composition, drastic changes in carbon dioxide concentration supposed to lead global warming with severe effects upon plant and insect diversity. Terrestrial arthropods are mostly dominant in trophic level. Therefore, impact upon them may lead to hamper overall trophic level interaction as well as ecosystem structure. It can be assumed that poor nutritional qualities of plant may lead to increases rate of mortality of many herbivores in upcoming century [86]. In plant, elevated carbon dioxide is responsible for altering plant physiological process thus indirectly leads to poor nutrition and development of insect. Among insect, butterflies have strong habitat specificity. However, fluctuation in atmospheric composition may reduce their habitat as well as mobility and restrict them in some specific geographic locations [87]. Combined effects of climate change at lower tropic level and stresses of abiotic factors makes higher tropic level species more sensitive to such condition [88]. However, narcoleptic and behavioural changes of insect unlikely to affect because of elevated carbon dioxide [89]. Specificity of resources, geographical distribution and dispersal capability are the potential life history traits to study the response of insect under climate change [90]. In this regard, being a radioactively active greenhouse gas as well as their drastic fluctuation trend, carbon dioxide was supposed to go along with the large swings in global climate over the Phanerozoic [91]. Thus against this effect of atmospheric fluctuation of carbon dioxide concentration, evolution of land plant community is likely to be interlinked. Fluctuations in atmospheric CO_2 have direct impact over physiological processes of plant. Stomatal closer was found to be more active under elevated carbon dioxide (92) which caused reduction in transpiration of plant. A number of studies [93],[94] reported 45% reduction in stomatal conductance as result of decrease density of stomata as well as stomatal aperture under carbon dioxide elevation. In this context, [95] also reported decreased stomatal conductance under same condition. Rate of photosynthetic in elevated carbon dioxide is well documented in literatures. Direct effect of elevated carbon dioxide upon rate of photosynthesis in C_3 plant has already been established in a numbers of studies [96]. It was observed that photochemical efficiency was reduced [97] and thus further leading to increase exposure of photo inhibition under elevated carbon dioxide condition [98]. Stomatal conductance is another impact; however, their magnitude is supposed to vary between species to species. In general, elevated carbon dioxide leads to increase photosynthetic carbon (C) in leaves for which leaf area, canopy transpiration, contradicting water gains as well as demand for plant nutrient increase. Development of stomata is associated with atmospheric carbon dioxide level. Woodward [99] stated that sensitivity of stomata in some fossil plant in the background of elevated carbon dioxide. Suppression of respiration is assumed to interrelate the reduction of nitrogen content in plant tissue. Apart from this, direct effect of carbon dioxide upon plant respiration was reported, but their response is still under debate. However, in this context a numbers of studies reported reduced respiration rate in plant under in elevated CO_2 [100], [101].

Carbon dioxide elevation has crucial role over physiology, distribution and overall all dynamics of plant community. However, interactions between diversity of plant, level of carbon dioxide and carbon cycling are very difficult process to predict. In this regard, elevation of carbon dioxide supposed to be play important role in plant diversity via a number of indirect pathways. Structural alteration of plant community under enriched CO_2 condition get more emphasise in this context. Long term effect of carbon dioxide can be assumed as the reduction in whole plant respiration [102] as well as crucial for photosynthesis capacity. Current global change supposed to reduce overall productivity of ecosystem as result of species loss. With N_2-fixing capacity legumes can exchange carbon (C) for nitrogen (N) and thus advantageous over non-leguminous species under enriched carbon dioxide condition [103], [104], [105]. In this regard, legumes are supposed to be more sensitive under enriched carbon dioxide condition in a controlled environment [106].

CONCLUSION:

Carbon dioxide emits mostly at gas flaring sites. Being a greenhouse gases it involves in determining the earth's average temperature within the atmosphere as well as contribution in global warming. Myriad effects of elevated CO_2 upon insects comes via alteration of plant chemistry i.e. accumulation of more carbon, dilution of nitrogen, increases in levels of defensive compounds such as phenolics etc. Under such warming environmental condition reproductive capabilities of some insectsmay enhance as well as change their distributional ranges. Further, these effects may lead to abundance of some pest and disease vectors. Thus for a profound understanding of gas flaring effect on biological system originated from these operation of oil companies, it will helpful to focus the environmental status and accountable for maintaining ecological economics in future context.

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