Impact of Human Activity on Biogeochemical Cycles and Ecological Services

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Abstract

Population growth puts addition pressure on our resources. Our indiscriminate and irresponsible use of natural resources makes the situation worse. Large population means more arable land for food production and water for irrigation and more fertilizers and pesticides in the environment. Modern humans have accumulated an unusual accumulation of human biomass and its waste pollute the environment and disturb the global biogeochemical cycles. Man leads a comfortable and luxurious life and his actions have a global impact (1). Forests are also cleared to make space for homes, roads, educational facilities, industries, and more. To meet the demand for food, shelter and energy, environmental resources are being depleted at a rapid rate. Environment is capable of replenishing most of its resources over a certain period of time. However, over-exploitation of resources and human activities has led to many environmental problems, such as reducing ecosystem diversity, changing biogeochemical cycles, adversely affecting ecosystem services.

Key words: *human population, genetic diversity, biogeochemical cycles, ecosystem services.*

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Introduction

Man has tremendous power and his actions have a global impact. Forests are cleared, hill tops levelled and even land under water is reclaimed to provide space for establishments and agriculture. The soil is bared, natural ecosystems are destroyed and are replaced by agriculture, horticulture and animal farms. The beginning of such artificial systems marked the first step of humanity towards the civilized society. Man has become a powerful source now a days. He altered natural flora and fauna over a large surface of area of world. During the first 40–50 thousand years of existence man was the hunter and gatherer of food material. About 50,000 years ago, the total world population was estimated to be about 10 million only. The rapid growth of human population is a result of increasing food supply, agriculture, horticulture and domestication of animals.

In 1800 AD global population was around one billion, this was made possible due to rise in food supply and advancement in science technology. In 1930 AD it was two billion, in 1960 AD it was about three billion, in 1975 AD it was about four billion and in 1987 AD it became five billion. By the close of 2000 it crossed the six billion. By a conservative estimate, the world population is expected to be above 7.0 billion by the year 2010 AD and 8.25 billion by the year 2025 AD (2,3,4). Unlimited increase in the population density of a country effects on the individuals of that country. It leads to problem of health, hygiene and sanitation. Naturally the consequences of over exploitation of natural resources and pollution of environment has resulted in reduction in ecosystem diversity, changes in biochemical cycle and adverse effect on ecosystem services.

(A)Reduction in ecosystem diversity and complexity

Man sets an artificial agricultural system which protects the biomass. This increases efficiency of production as the energy needed to maintain a simple structure is much lower than the complicated ones (5). In a complicated ecosystem at each trophic level several alternatives are available for energy to flow and material to circulate in the system which is maintained in operative state (6).

Microbial community which is present in soil or water bodies are adversely affected by man. Use of chemical fertilizers leads to depletion of organic material on which microbial population grow. Man domesticate and protect few species. Species which are left out, cope up with the stress. This leads to severely damaging effect on grassland and forests (7).

A number of plant and animal species have become extinct or are on the verge of extinction. However, the strain placed by human activity has speeded up

the process of elimination of weaker species. Each extinct species takes away its gene pool, which took millions of years to evolve (8,9). Selection of varieties for better output, resistance to environmental conditions, better tastes and flavour has led a drastic reduction in genetic diversity of plants and animals. In 1980 AD only four varieties provide 72% of entire potato harvest in United States (10).

(B) Changes in biogeochemical cycles

Waste material discarded by man, exploitation and pollution of environment has disturbed all important biogeochemical cycles. Man has been extracting substantial quantities of mineral at a much faster rate than the rate of formation. As a result they are depleting at a very fast rate.

1. Changes in carbon cycle

Carbon occur as carbon di oxide in atmosphere, as organic compound in plants and animals and as inorganic form in water, rock, shell etc. due to increased use of organic matter, coal, petroleum, fuels and combustion of carbonate rocks for the manufacture of lime and cement, the rate of input of carbon in atmosphere enhanced. Rapidly growing population modifies the natural ecosystem by deforestation, faulty agriculture practices, intensive grazing etc.. Lead and DDT reduces photosynthetic activity of green plants on global scale. Due to these reasons there is more input of carbon di oxide rather than output.

Carbonate rocks are the largest reservoir of carbon on our planet. In ocean of the world carbon is present in the form of dissolved carbon di oxide, bicarbonates, carbonates etc. In 1750AD the concentration of carbon di oxide in the atmospheres was 278 ppm, now it is about 380 ppm. (11,12,13). Rising concentration of Co_2 threatens the mankind with following effects-

Global warming and climate change

A small rise in Co_2 conc. Shows no effect on plants and animals however, a high cons. of Co_2 acts like a big blanket around the globe which obstruct loss of heat from Earth's atmosphere, due to this rise atmosphere and ocean warm up. Mean global temperature have increased by 0.74±0.18 during the last 100 years ending in 2005. Climate model indicate that there could be further rise of 1.1 to 6.4^{o}C temp. by the end of twenty first century. A rise of few degree may seem small but this could have disastrous effect for the whole world (14).

Danger of ocean acidification

About 48% of Co_2 is absorbed by ocean. This Co_2 when dissolved in water produces an acid which lowers the pH of water (15). Our ocean are slightly alkaline having a pH of about 8.104. ocean acidification dissolve more and more

calcified structures and change the chemistry of water. It could cause adverse ecological changes in nature, and flora and fauna of marine. Between 1751 and 1994 surface ocean pH decreased approximately 8.179 to 8.104 and by the end of 21st century it could go down up to 7.824 (16,17).

2. Changes in Oxygen cycle

Atmospheric oxygen is a major reserve of oxygen gas. In combination with hydrogen it occurs in water, with carbon it occurs as carbon di oxide, in the form of carbonates and bicarbonates. It is an important constituent of organic matter. Photosynthesis, respiration and many oxidation reactions require oxygen (18,19). Oxygen has given rise to ozone umbrella, which protects terrestrial habitat from harmful solar radiation. Since the level of oxygen in atmosphere determine ozone concentration it was only when enough oxygen could accumulate in the atmosphere to form an effective ozone shield. This happened about 440 million years ago, in Silurian period when oxygen concentration rose up to 1/10 of the present day oxygen level (20). Disturbed oxygen cycle pose several problems to humanity as-

Our diminishing oxygen reserves- The main process for oxygen production is photosynthesis which has been estimated to produce about260 gm of oxygen per sq. metre per year. Almost equal amount of oxygen is consumed in respiration and other oxidation reaction. The quantity of oxygen is required for burning coal, petroleum and natural gas has been estimated to be 10-11 gm per sq. metre per year which comes from atmospheric pool and shows no detectable effect on global cons. of this gas. So we are reducing our oxygen reserve by 3-5 ppm every year (21).

3. Changes in nitrogen cycle

Nitrogen is an essential element for all living organism. The main reserve of nitrogen is atmospheric air, rock deposits and living and dead organic matter. The cyclic flow of nitrogen in an ecosystem involves a precise balance of activity of a few species of bacteria so that adequate levels of nutrients are maintained without excessive accumulation of inorganic and organic compounds of nitrogen (22,23,24). Human activities disturb nitrogen cycle. It is having serious impact on ecosystem around the world because it is essential for living organisms and its availability plays a critical role in the organisation and functioning of worlds ecosystem (25).

Increased cons. of nitrous oxide and nitric oxide have been causing great concern these days. Nitrous oxide is a potent greenhouse gas and with nitric oxide it forms photochemical smog in the atmosphere. Atmospheric reaction converts oxides of nitrogen into an acid which forms acid rain. In the stratosphere oxides of

nitrogen contribute to ozone depletion catalytically (26). Higher conc. of nitrates enhances emission of nitrous oxide from the soil. Which results in acidification of soil and of waters of stream and lakes. These negatively charged ions nitrate ions seep away and carry with them positively charged alkaline mineral such as calcium, magnesium and potassium. Thus, human modification to nitrogen cycle decreases soil fertility by the loss of several nutrients which are vital for plant growth (25).

Most of the natural system are adapted to a limited supply of nitrogen but new supply of nitrogen upon these ecosystem reduce species diversity. Species well adapted to high level of nitrogen in the soil compete the ill adapted ones which are either lost or are represented by very low population (27).

4. Changes in phosphorus cycle

Phosphorus is more abundant in living organisms than in abiotic system. Phosphorus is solubilized from its deposits under low pH condition and is taken up by plants. Plants and animal secretion and decomposition of dead organic material bring it back to the surrounding medium. In oceans it is in the form of phosphate rocks, guano deposits and bone deposits. Only a little amount of phosphorus returns to land from oceans through birds and guano birds while much of its is lost to deep sea deposits (28,29). We intervene in the Earths phosphorus cycle in the following ways-

This cycle was in the balanced state up to 1900AD. Rapid soil erosion has greatly enhanced the rate of loss of it from soil to sea. We mine large quantities of phosphate rocks to make commercial inorganic chemical and fertilizers. About 70-80% of the industrially produced phosphorus is applied to agricultural fields. Some phosphorus is used in the manufacture of soap and detergents which are discharged directly into freshwater streams or oceans and it causes nutrient enrichment, excessive algal growth and other problems (30).

5. Changes in sulphur cycle

On earth crust major reserves of sulphur are deposits of sulphide and sulphates. A number of metals occur as sulphide or sulphate deposits which during their mining and processing operation eliminate sulphur di oxide gas and this is added to the environment. There are two major factors contributed by human beings which disturb natural sulphur cycle. A lot of sulphur is added to atmosphere as a result of mining and processing operation during extraction of metals. Volcanic emission is the only source of sulphur di oxide, and have been estimated to contribute 2×10^9 to 5×10^9 kg of sulphur per year, while the annual amount of industrial sulphur injected into atmosphere is thought to be about 83×10^9 kg. (30).

Certain marine algae produce large amount of volatile dimethyl sulphide or DMS. In the atmosphere DMS is converted to sulphur di oxide. This sulphur di oxide, from natural sources and human activities is converted to sulphur tri oxide gas and to tiny droplets of sulphuric acid.in addition it reacts with other atmospheric chemicals such as ammonia to produce tiny particles of sulphate salts. These droplets and particles fall to the earth as components of acid deposition which harm trees and aquatic life.

6. Changes in trace elements of biogeochemical cycle

In addition to major elements there are a number of trace elements which also circulate in the environment. Some of them are essential and some are substitute of them and some simply circulate in biosphere along with other materials. Some of these elements may also combine with organic molecules to form volatile organometallic compounds and contaminate atmosphere. It is mainly human activity which disturb the natural cycle of these elements. Important trace elements which are causing environmental problem these days are lead, mercury, cadmium, chromium, arsenic, zinc and nickel etc.. Industrial production, combustion of coal, petroleum and their mishandling during processing, transportation and storage release these elements in a much higher concentration than those attained during their natural cycling. We are exploiting these elements at a much faster rate than they are being laid down. There may come a time when there are no economically viable deposits left for our use (31).

(C) Disruption of ecological services

Services rendered by natural ecosystem to humanity are invaluable and irreplaceable. Natural ecosystem provides us a number of commodities like edibles, spices, medicines, pharmaceutical and industrial products. Healthy ecosystem carries out a number of essential jobs without which mankind cannot survive. Most of these services are provided by a variety of microbes, plant, animals and biodiversity. But all these are being dismantle by human activity. Some consequences of the rapid degeneration of biodiversity are as follows-

Natural ecosystem posses a vast collection of biodiversity of which some are known but some are still unknown to mankind. This unknown biodiversity may possess many important species which could be used to feed mankind and could be of industrial use (32). Human activity has been damaging our soil by excessive use of fertilizers and pesticides. This has resulted in nearly 70 % of the global area of arable land being affected and has lost nearly one third of its productive capacity with about 19.85% being in the critical condition (33).

Natural ecosystem, which are used to limited supply of nitrogen are saturated with salts of nitrogen. decomposition of organic matter under oxygen deficient condition produces methane, a greenhouse gas, while combustion yield Co_2 which add to the concentration of greenhouse gases in the atmosphere. All these affect natural ecosystem which disrupt the services they provide (32a). faulty agriculture practice, excessive use of nitrogenous fertilizers, insecticides, pesticides have a detrimental effect on natural nitrogen fixing machinery (34).

Today we are adding more and more carbon di oxide gas to the atmosphere and disturbing vital cycle of photosynthesis. This is expected to enhance the rate of global warming and climate change. Through land use modification we are altering the albedo over a large area of Earth's surface which results in changes in local climate and pattern of precipitation (35).

Invasive species threaten biodiversity, change ecosystem structure and function and adversely affect ecosystem services. In healthy ecosystem rich diversity of life forms provide resistance to invading species. But in system disturb by human activity this resistance is lost (36).

In natural ecosystem a process of check and balance is operative which automatically controls populations of diverse insects, pest and pathogens. Human activity disturbs this system and reduces richness and biodiversity. Insect, pest and pathogens multiply and cause great loss to plants, animals and even humans (37). Nearly one third of worlds food production relies either directly or indirectly on insect pollination. In order to persist in agro-ecosystem pollinators need local floral diversity and nesting sites. Pollination limitation also leads to increased inbreeding, reduced genetic fitness and increased susceptibility to environmental stress (38).

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